ENVIRONMENTAL ASSESSMENT
OF THE
CARTERET IMPOUNDMENTS
AMERICAN CYANAMID COMPANY
LINDEN, NEW JERSEY

PREPARED FOR

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EXECUTIVE SUMMARY

This report present a review of the hydrogeologic and water quality conditions in the vicinity of American Cyanamid Company's Carteret Impoundments (the "Site"). It is primarily based upon the results of the quarterly groundwater monitoring program conducted from July 1987 through October 1988. Hydrogeological characterizations are based upon information obtained at the time of the installation of the groundwater monitoring wells and upon work performed at the Site in preparation for the initial Discharge to Groundwater Permit Application.

In addition to reviewing the results of the monitoring program from a technical perspective, the report evaluates:

a. whether sufficient data are available to develop appropriate groundwater quality standards at this time, and

b. whether there is a need for corrective action at the impoundments.

The Carteret Impoundments are a closed facility located in an industrialized section of Carteret, New Jersey off Driftway Drive. The impoundments accepted sludges from the production of alum and Yellow Prussiate of Soda (YPS) from 1939 to 1973. During this time, sludge was placed in a series of six impoundments which ultimately covered approximately 100 acres. Currently, American Cyanamid is undertaking a program to establish permanent vegetation at the Site. This revegetation project will be completed in 1989.

Geologically, the Site is underlain by Quaternary alluvium consisting of silt, sand, clay and some gravel with buried organic rich meadow mat. The alluvium overlies the Triassic aged Brunswick Formation which consists of a dense, hard siltstone in the vicinity of the Site.

Five sets of paired monitoring well clusters were installed at the Site in 1987 to provide monitoring of a shallow and a deep groundwater zone. Five wells were screened from depths of 10 to 20 feet in the shallow, black organic-rich sand/meadow mat and fill material and are designated "S" wells. Four wells were screened in the upper part of the Brunswick Formation at depths from 40 to 60 feet. One deep well was screened just above the Brunswick Formation in a gravel layer at a depth of 25 to 35 feet. These deep wells are designated "D" wells.

Shallow groundwater is mounded beneath the impoundments, and groundwater flow is radially outward from the central area of the impoundments. The shallow groundwater originating within the impoundments discharges into the surrounding surface water. The groundwater monitored in the deeper zone appears to be confined and hydraulically separated from the shallow zone by the intervening red-brown clay layer that was found under most of the Site. The

clay was not found in MW-5D, though. Groundwater flow in the deeper zone appears to be towards the north and northeast where it probably is discharging into the Rahway River, Arthur Kill, and Atlantic Ocean.

As expected, the shallow groundwater contains elevated levels of ammonia, cyanide, sulfate, and possibly sodium. Concentrations of total cyanide (free and complexed cyanide dissolved species) were detected above background in shallow wells MW-2S, MW-4S and MW-5S at average values of 25 mg/l, 103 mg/l and 4.2 mg/l, respectively. Ammonia concentrations in MW-2S, 4S, and 5S are elevated above the average background level of less than 8 mg/l with average values of 164, 410, 26.7 mg/l, respectively. Sodium concentrations are elevated by a factor of approximately two over background with averages of 5,235 mg/l in MW-2S, 8,442 mg/l in MW-4S, and 7,093 mg/l in MW-5S. Sulfate concentrations are elevated by a factor of approximately five to ten over background with averages of 4,658 mg/l in MW-2S, 3,325 mg/l in MW-4S.

Generally, these same constituents have not been detected in the deeper groundwater zone. For the deep monitoring wells, only MW-5D samples were reported to have significant levels of total cyanide with an average of 10.8 mg/l. These cyanide levels are similar to those reported for MW-5S which averaged 4.2 mg/l. However, these levels are much lower than those detected in the shallow wells MW-2S and 4S. Since the clay confining layer was not found in MW-5D, the shallow and deep wells at this location could be expected to have similar chemical characteristics. Well MW-4D samples had an average total cyanide concentration of only 0.54 mg/l. No other inorganic constituents in deep well samples are significantly above concentrations in the background well MW-1D.

Based on the results of a chemical loading rate model and confirmed by surface water sampling conducted in the Rahway River and several tributaries, there is no detectable impact of the impoundments on surface water quality.

The Administrative Consent Order (ACO) between NJDEP and American Cyanamid presents numerical groundwater standards used to review the groundwater monitoring data and evaluate the impact of the facility on groundwater quality. The numerical standards contained in the ACO correspond to a GW/3 groundwater classification scheme under NJAC 7:9-6.1 et seq. The groundwater monitoring data for the facility clearly illustrate that the total dissolved solids (TDS) concentration exceeds the 500 to 10,000 mg/l used for the GW/3 classification. Thus, the Carteret Impoundments should be evaluated under the GW/4 classification scheme for which standards are set on a case-by-case basis.

Based on the results of this Assessment, it may be concluded that the impact of the Carteret Impoundments on the local groundwater and surface water is negligible. No corrective action appears warranted at this time.

With respect to the development of possible future groundwater protection standards for the impoundments, it is noted that NJDEP is currently considering substantial revisions to the State Ground Water Quality Standards including policies, classification system, use designations, and numerical criteria. Pending the development and promulgation of the revised standards, it is suggested that the derivation of the site-specific standards for the Carteret Impoundments be deferred. In the interim, routine monitoring can be continued to confirm the absence of significant adverse health or environmental impacts, while improving the data base from which the standards may ultimately be developed.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to present a summary and compilation of the hydrologic investigations of the Carteret Impoundments (hereinafter referred to as the "Site"). This assessment summarizes the impacts of the impoundments on the underlying groundwater and adjacent Rahway River, and formulates recommendations concerning the Site.

Subsurface and hydrologic investigations compiled for this report include the following.

Preliminary report of test borings and dike evaluation at the impoundments, prepared by M. Disko Associates, January 1982.

Surface water, and groundwater investigations completed by HYDROSYSTEMS in 1986.

Data obtained during monitoring well installation at the Site, supervised by HYDROSYSTEMS, Inc. in May, 1987.

Groundwater monitoring results for six quarterly groundwater sampling events, July 1987 through October 1988.

The specific objectives of this environmental assessment of the Carteret impoundments include the following.

1. Summarize the findings of various studies at the site which characterize its hydrogeology.

2. Review the analytical results for the groundwater monitoring program and identify any data trends and data gaps.

3. Establish the relationship between the Site's hydrogeology and the results of the groundwater monitoring program.

4. Characterize the behavior and fate for any potential constituents of concern along the groundwater and surface-water migration pathways.

5. Identify potential receptors of the constituents of concern released by the impoundments, and evaluate the human health and environmental risk presented by any such release.

1.2 Site History

Figure 1 shows the location of the Carteret impoundments on a portion of the Arthur Kill, New York-New Jersey topographic quadrangle map. The impoundments were used from 1939 to 1973 for the disposal of acidic sludge from an alum process and alkaline sludge from the yellow prussiate of soda (YPS) process.

The production of alum involved the digestion of bauxite ore with sulfuric acid. The resulting muds, primarily silica, were slurried with water, neutralized, and pumped to the impoundments for settling. The production of YPS involved the reaction of calcium cyanide with copperas (hydrated ferrous sulfate) and soda ash to form sodium ferrocyanide. The resulting muds, primarily calcium carbonate, were slurried with water, neutralized, and pumped to the impoundments for settling.

The sludges from the two processes were combined in the impoundments to form a near neutral sludge. A series of six impoundments was constructed above ground with wooden and earthen dikes. The sludges were pumped from the plant on the north side of the Rahway River to the impoundments through an above ground pipeline. The impoundments eventually covered approximately 100 acres and are estimated to contain just under two million tons of sludge.

Figure 1. Location map for the Carteret impoundments, Carteret, New Jersey.

1.3 ON-GOING WORK AT THE SITE

Over the past eight years, American Cyanamid has been undertaking a major project to vegetate and stabilize the sludge. The sludges in the impoundments are deficient in several essential nutrients necessary for plant growth. Phosphorus concentrations are minimal and organic content is extremely low. Cyanamid studied the augmentation of nutrients in the sludge and, beginning in 1986, undertook to establish vegetation on the sludge surface using a composted sewage sludge product to provide essential nutrients. Approximately 75% of the Site has now been vegetated. The vegetation of the remaining impoundment will be completed during the 1989 growing season.

The vegetation project has had a number of benefits. These include:

1. The sludge is stabilized and less susceptible to erosion and wind dispersal.

2. In the absence of vegetation, the sludge is thixotropic and has a very low bearing capacity. Vegetated areas have adequate bearing capacity to support individuals and light vehicles.

3. The vegetation project has established a community of perennial plants which is expected to decrease infiltration and leachate production through the increase in evapotranspiration.

The impact of the vegetation project on groundwater and surface water conditions at the Site is unknown at this time. Monitoring results will be reviewed over a period of years to assess the results of the vegetation project.

2.0 SITE INVESTIGATIONS

2.1 Pre-Permit Investigations

Geotechnical investigations at the Carteret Site have been conducted over the past 10 years. In 1981, M. Disko and Associates completed test borings within the sludge impoundments (approximate test boring locations shown in Figure 2). In May of 1986, HYDROSYSTEMS conducted preliminary investigations of sludge and leachate quality involving the collection of grab samples from hand augered borings. Subsequently, in October 1986, HYDROSYSTEMS conducted a systematic sampling of surface water with upstream and downstream stations in the Rahway River.

2.2 Monitoring Well Installation

In 1987, in response to NJPDES/DGW permit requirements, ten monitoring wells were installed under the supervision of HYDROSYSTEMS at five locations with screens set at shallow and deep zones. All wells were located outside of the impoundments. The approximate locations of the wells, numbered MW-1 through MW-5, are also shown in Figure 2. Each cluster consists of two wells: a shallow well, designated "S", screened in the fill, black organic sand or red-brown clay overlying the Brunswick Shale; and a deep well, designated "D", screened in the Triassic-aged Brunswick Formation or a sand and gravel layer overlying the Brunswick in the case of MW-5D.

The wells were drilled with a mud-rotary rig using bentonite drilling fluid. An 8-inch rock drill bit was used and all wells were installed with 4-inch ID, Schedule 40, flush-jointed, threaded PVC well casing and 10 foot lengths of 0.020-inch machine slotted PVC well screens. Sand pack consisting of coarse-grained #2 quartz sand was placed around each well screen to a minimum of one foot above the top of the screen. Approximately two feet of bentonite pellets were placed above the sand pack to form the seal. The wells were then grouted to about two feet below ground surface with a 5% bentonite/cement slurry. Steel casings with locking caps were installed and cement was brought to the surface. Monitoring well construction diagrams and geologic logs are included in Appendix A. Also, the State of New Jersey permit to drill the well and the monitoring well certification, Form A, for each well are included in Appendix A.

The wells were developed after installation by pumping with a 4-inch submersible pump until the discharged water remained clear of silt and drilling fluid. Approximately one week after the initial development, the wells were developed again using a suction lift centrifugal pump and bailer.

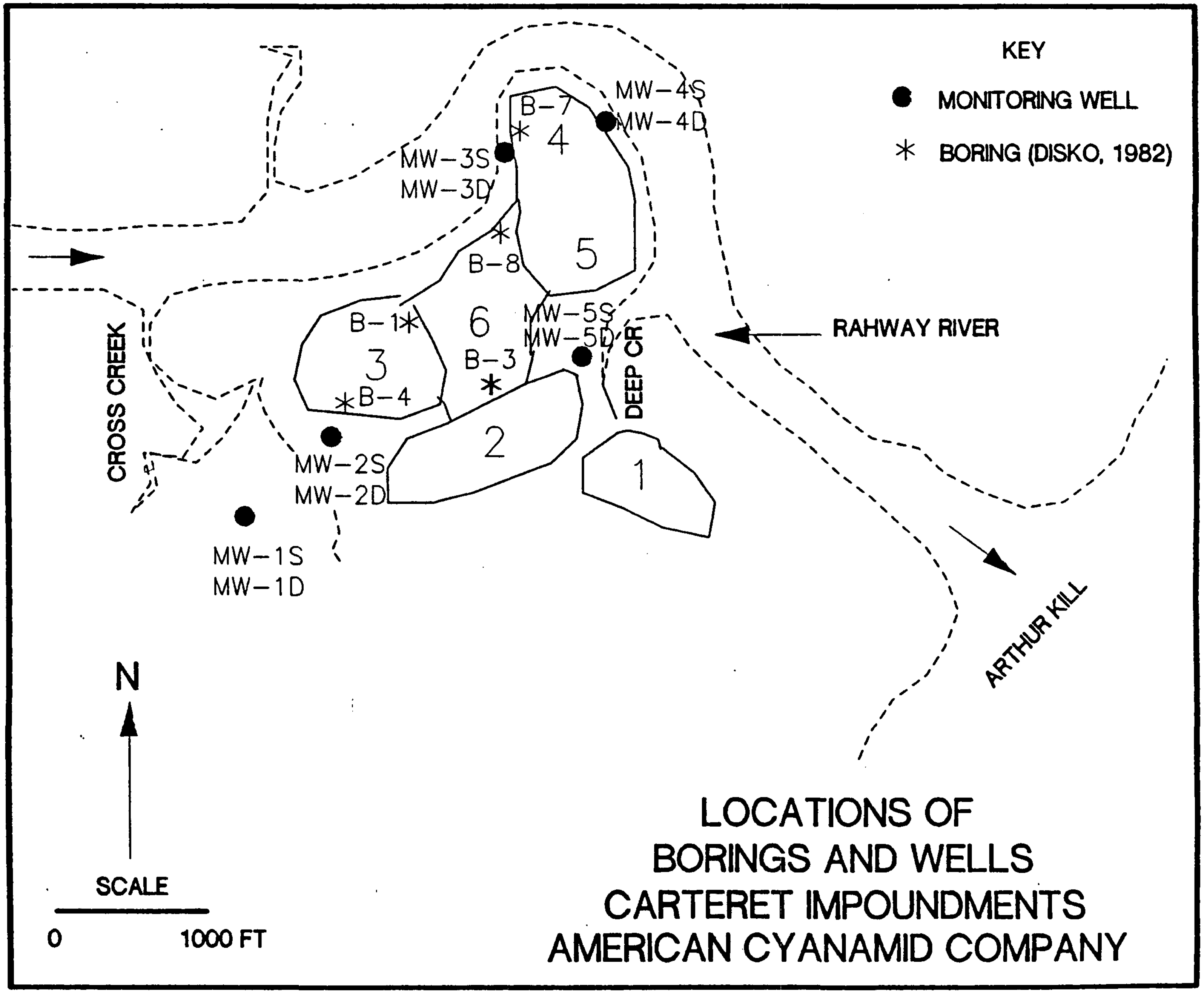

Figure 2. Site map showing the locations of the borings installed by M. Disko Associates at the Carteret Impounds in 1981 and the monitoring wells installed in 1986.

3.0 SITE CHARACTERIZATION

3.1 Solid Waste Characterization

In May of 1986, HYDROSYSTEMS conducted investigations to characterize the quality of the sludge. The specific tests included field pH of sludge pore water, total and free cyanide, and extractable (EP Toxicity) metals. Samples from five borings, the locations of which are shown in Figure 4, were collected for analysis.

Field pH measurements of sludge pore water were made using "colorpHast" brand pH indicator strips, a product of EM Science (catalog no. 9590, pH range of 0-14). Results of the field pH measurements are presented in Table 1, and indicate the near-neutral condition of the mixed alum/YPS sludge.

Seven samples of sludge were analyzed for EP Toxicity (metals) and total and free cyanide content. Two of the seven sludge samples were duplicate samples from the same borings. Table 2 presents the results of the EP Toxicity and cyanide analyses for the sludge samples. Laboratory data for these analyses are included in Appendix B. The results of the pH and EP Toxicity tests indicate the sludge is nonhazardous under RCRA regulations. Free cyanide levels were also substantially below SW-846 threshold levels which would characterize the materials as hazardous waste, i.e., 250 mg/kg releasable cyanide.

TABLE 1. Field pH of leachate in contact with sludge in the Carteret impoundments.

BORING NO.	FIELD pH OF LEACHATE IN CONTACT WITH SLUDGE
B1b	7
B2	7
B4	7
B5	7
B6	8
B7	8

TABLE 2. Laboratory analyses for EP Toxicity and Free and Total Cyanide content in sludge samples from the Carteret impoundments.

PARAMETER	METHOD OF ANALYSIS (NOTE 1)	DETECTION LIMIT (ug/l)	EP TOXICITY CRITERIA (ug/l)	SAMPLE NO.- BORING NO.- IMPOUND NO.-	C1 B1a 4	C2 B2 5	C2* B2 5	C3 B3 6	C4 B4 3	C4* B4 3	C5 B5 2	LAB BLANK
								(ug/l)				
ARSENIC	ICP	200.0	5,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
BARIUM	ICP	200.0	100,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
CADMIUM	ICP	50.0	1,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
CHROMIUM	ICP	50.0	5,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
LEAD	ICP	200.0	5,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
MERCURY	CV	0.3	200.0		BDL	BDL	BDL	0.57	0.69	NA	BDL	BDL
SELENIUM	ICP	200.0	1,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL
SILVER	ICP	50.0	5,000.0		BDL	BDL	NA	BDL	BDL	BDL	BDL	BDL

UNITS FOR CYANIDE ANALYSES IN MG/KG
AVERAGE

TOTAL CYANIDE	335	0.5	NONE		683	452	NA	3660	437	NA	433	NONE
FREE CYANIDE	412	0.5	NONE		14	18	NA	103	38	NA	9	NONE

NOTES:

1. ICP = INDUCTIVELY COUPLED PLASMA SPECTROMETRY
   CV = COLD VAPOR ATOMIC ABSORPTION SPECTROSCOPY
   335 = METHOD 335.2 OF STANDARD METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTE, EPA-600/4-79-020, REVISED MARCH 1983.
   412 = METHOD 412 OF STANDARD METHODS, 16TH EDITION 1985.

2. BDL = BELOW DETECTION LIMIT
   NA = NOT ANALYZED
   * = DUPLICATE

3.2 Geology

The inactive alum impoundments at Carteret are located on the boundary between the Piedmont and Coastal Plain physiographic provinces. Surficial deposits consist of about 20 to 40 feet of Quaternary alluvium composed of interbedded silt, sand, gravel, and clay with buried peat and organic rich horizons. This alluvium was deposited in a brackish estuarine, salt-marsh environment (Nemickas, 1976).

Bedrock underlying the alluvium is the Triassic-age Brunswick Formation generally consisting of bedded shales, mudstones and sandstones which attain a maximum thickness of 6,000 to 8,000 feet in New Jersey (Nemickas, 1976). The Brunswick Formation encountered at the impoundments consists of a dense, hard, red siltstone.

During monitoring well installation, split-spoon samples were collected in the unconsolidated sediments and fill material. Geologic logs were prepared for each well cluster (included in Appendix A). Cross-sections have been developed from these logs and those presented by Disko (1982) for the Site. The locations of the cross-sections are shown on Figure 3 and the cross-sections are presented in Figures 4 and 5. The logs for MW-1, MW-2, MW-3 and MW-4 indicate the presence of 10 to 25 feet of a black organic sandy silt, corresponding to the meadow mat, gray organic silt, and sand and gravel zones encountered in the Disko (1982) borings. The shallow wells at these four locations were screened in the black, sandy silt and red/brown clay. A continuous zone of red-brown clay, approximately 8 to 25 feet thick, exists beneath the organic sandy silt in these wells and corresponds to the red clay layer present in Disko (1982) borings B-1 and B-4 (see Figures 4 and 5).

A dense, hard, red and grey siltstone, typical of the Brunswick Formation, was encountered beneath the clay at a depth of from 30 to 42 feet in MW-1 through MW-4. The deep wells at these locations were screened in the upper part of the Brunswick Formation. The black organic-rich sandy silt layer encountered in the other wells was not encountered in MW-5S. Therefore, the screen for MW-5S was set in the lower part of the fill and upper part of the clay zone beneath the fill. This clay is most likely the same clay strata encountered in MW-1 through MW-4.

Beneath the clay at MW-5D, a zone of red-brown and grey sand and gravel was encountered overlying the Brunswick Formation. (The screen for MW-5D was set in this sand and gravel zone, rather than in the Brunswick Formation to allow sampling of groundwater from the more permeable zone.)

3.3 Hydrostratigraphy

The shallow groundwater zone consists of the permeable fill material, meadow mat, and black organic-rich sandy silt. The water table was encountered at a depth of approximately 2 feet below ground surface in the shallow wells. The Brunswick Formation contains the deep groundwater in the area and transmits groundwater through fractures in the siltstone. The sand and gravel layer encountered in MW-5D is most likely in hydraulic connection with the underlying Brunswick Formation.

Figures 4 and 5 show cross-sections A-B and C-D, located in Figure 3, which indicate that the Brunswick Formation is overlain by a clay confining layer. The clay strata appears to be continuous across the Site except in the vicinity of Disko's (1982) boring B-3. The clay strata probably acts as a confining layer for much of the underlying Brunswick Formation (and gravel layer encountered in MW-5D). Where present, the clay strata acts to restrict the vertical flow of groundwater between the shallow and deep groundwater zones.

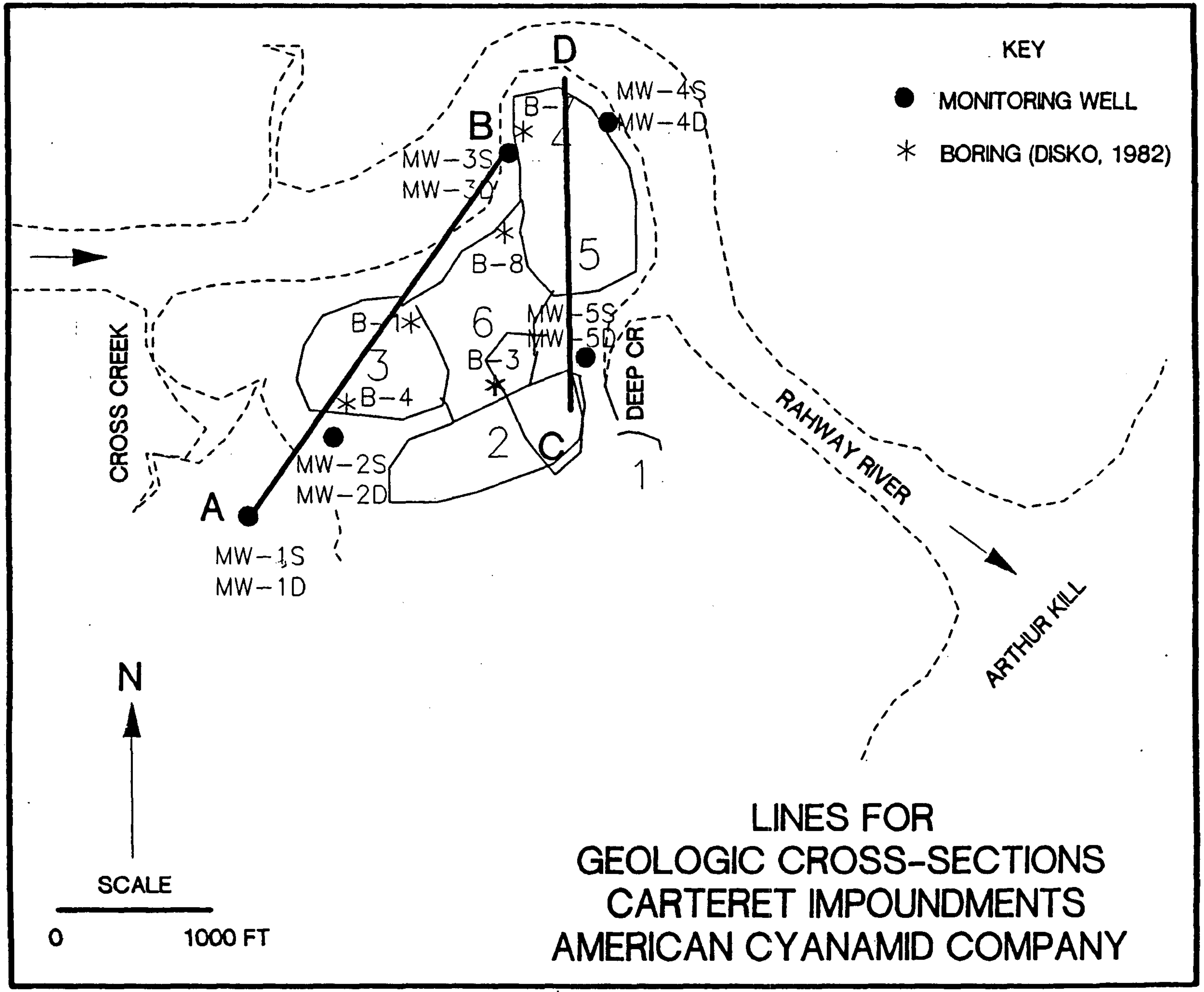

Figure 3. Locations of geologic cross-section A-B and C-D.

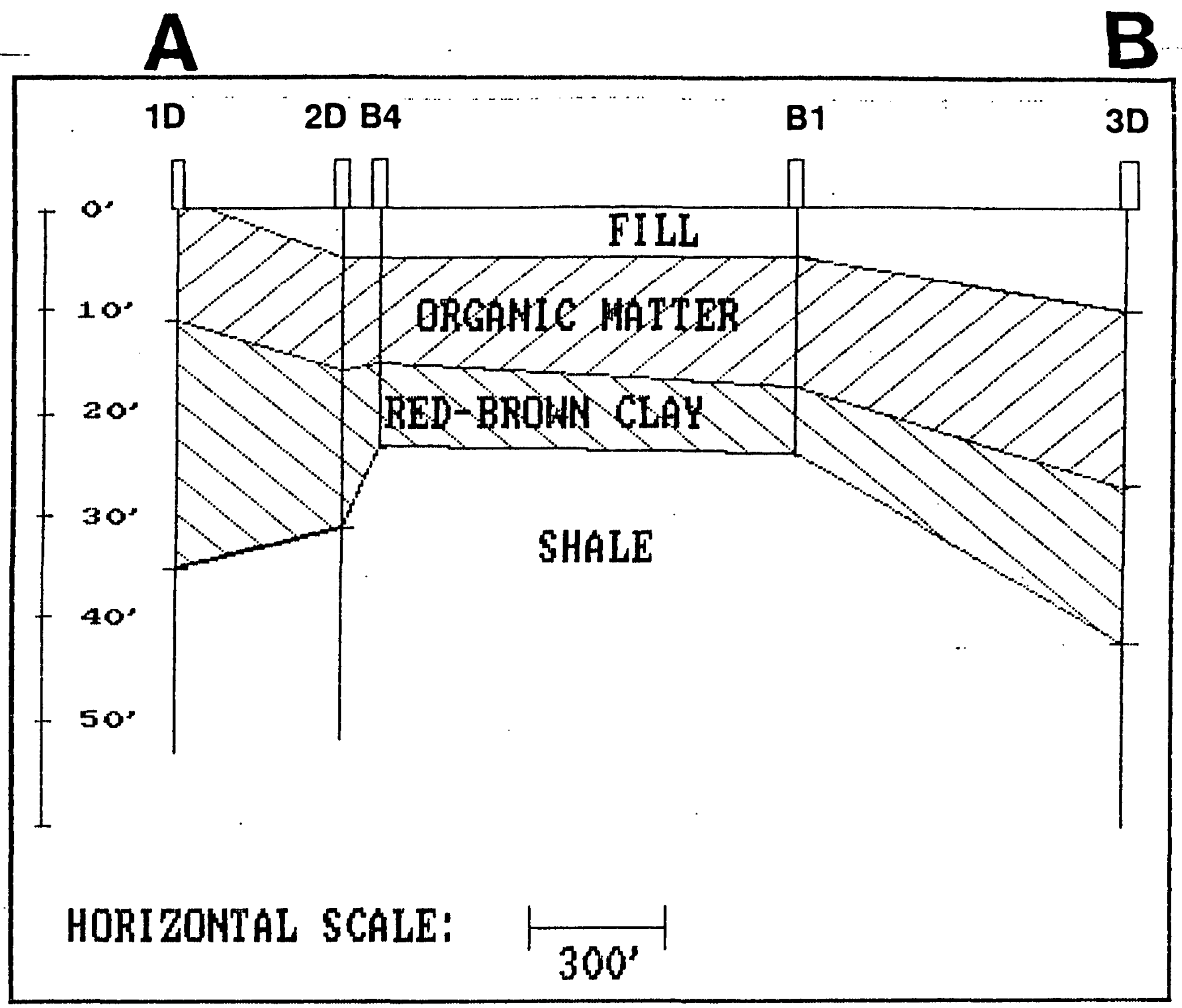

Figure 4. Geologic cross-section along line A-B shown in Figure 3 for the Carteret Impoundments.

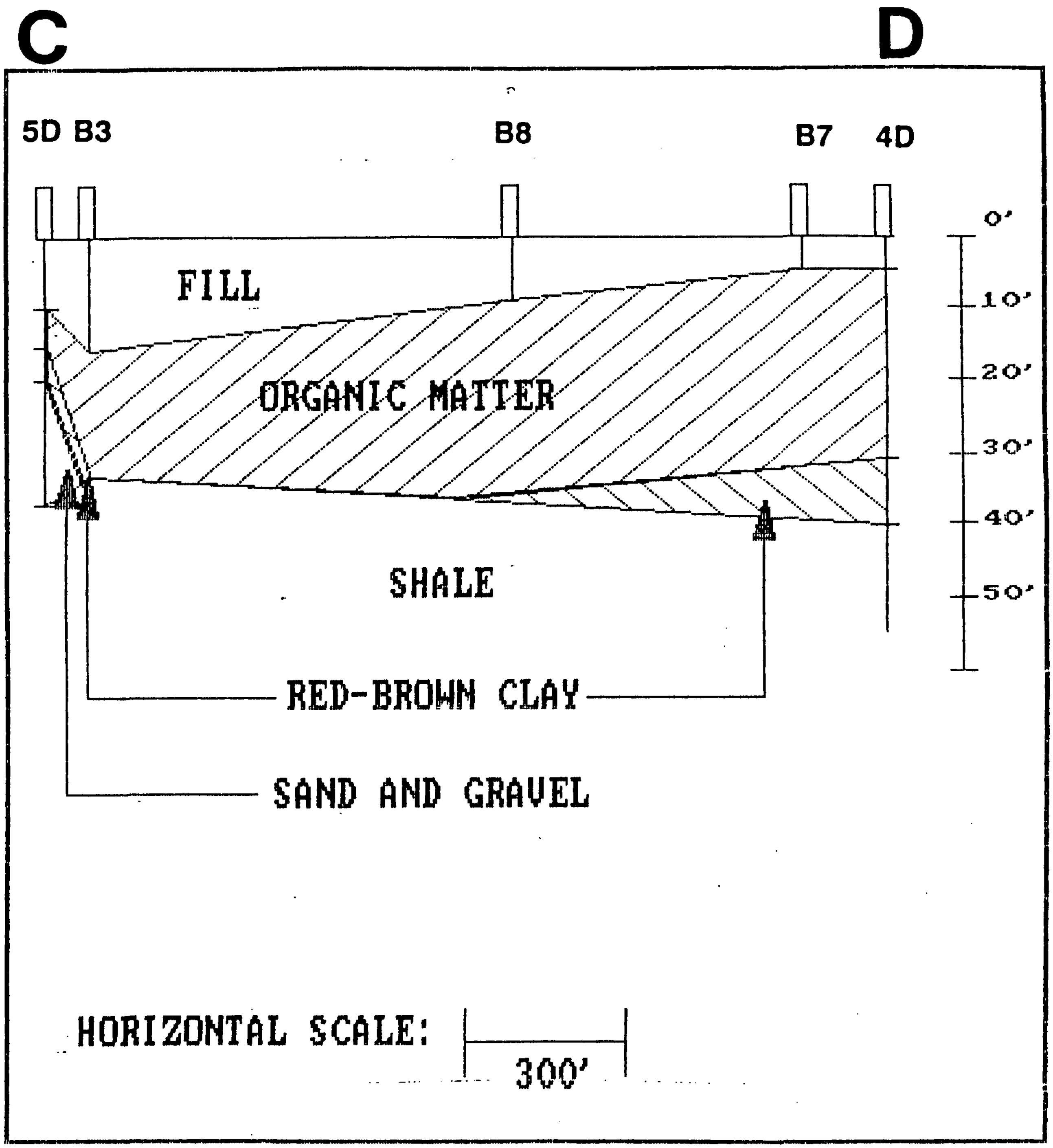

Figure 5. Geologic cross-section along line C-D shown in Figure 3 for the Carteret Impoundments.

3.4 Aquifer Properties

Disko (1982) completed permeability tests on subsurface samples, and reported hydraulic conductivities ranging from 2 x 10^{-6} to 3.8 x 10^{-3} cm/sec (0.006 to 10 ft/d) for the clay, sand, and gravel materials he encountered in the upper 24 feet underlying the impoundments. Effective porosity for the shallow aquifer material is estimated to average 20% for sands and gravels and 5% for clays and clayey silts (Walton, 1970).

3.5 Groundwater Flow

Water levels were measured in the 10 monitoring wells prior to evacuation and sampling for each quarterly monitoring event. The measured depth to water and casing elevations are provided in Appendix A. The water level elevations were calculated, and generalized groundwater contour maps were constructed for both the shallow and deep zones and are presented in Figures 6 and 7. Estimated water table elevations determined by HYDROSYSTEMS while installing the hand-augered borings in 1986 were also used to prepare the contour map of the shallow zone. These data are for the time prior to the vegetation project.

The contour map presented in Figure 6 indicates that, at that time (1986-87), shallow groundwater was mounded beneath the impoundments, and flowed radially outward from the impoundments toward the Rahway River, Deep Creek, and Cross Creek. The water table mound centered on impoundments 4, 5, and 6, which are the highest topographically. The mound had an elevation approximately 10 feet above mean sea level beneath these impoundments. The generalized contour map of groundwater elevations prepared for the deep zone indicates a groundwater flow towards the north and northeast (See Figure 7). Interpretation of the water level data for the deeper zone supports the conclusion based on stratigraphic evidence (see Section 3.3) that the shallow and deep zones are separated hydraulically by the red-brown clay over most of the area (except at MW-5D where the clay was not found).

Figure 8 shows a generalized north-south cross-section through the impoundments. The regional groundwater flow in the Brunswick Formation is seaward and upward toward the northeast with discharge to surface water including, potentially, the lower Rahway River, Arthur Kill, and, eventually, the Atlantic Ocean. The groundwater originating within the impoundments moves radially outward and discharges into the surface water surrounding the impoundments, i.e., the Rahway River, Cross Creek, and Deep Creek.

Groundwater originating within the impoundments is further isolated from the regional groundwater by a groundwater density contrast. The mounded groundwater within the impoundments is less dense, with a specific conductivity of about 1,000 umhos/cm, or a total dissolved solids (TDS) of about 600 mg/l (Hem, 1970, p. 100), than the underlying groundwater in the shallow and deep zones with a TDS ranging from about 15,000 to 25,000 mg/l. Therefore, the less dense groundwater within the impoundments tends to "float" on top of the underlying brackish groundwater.

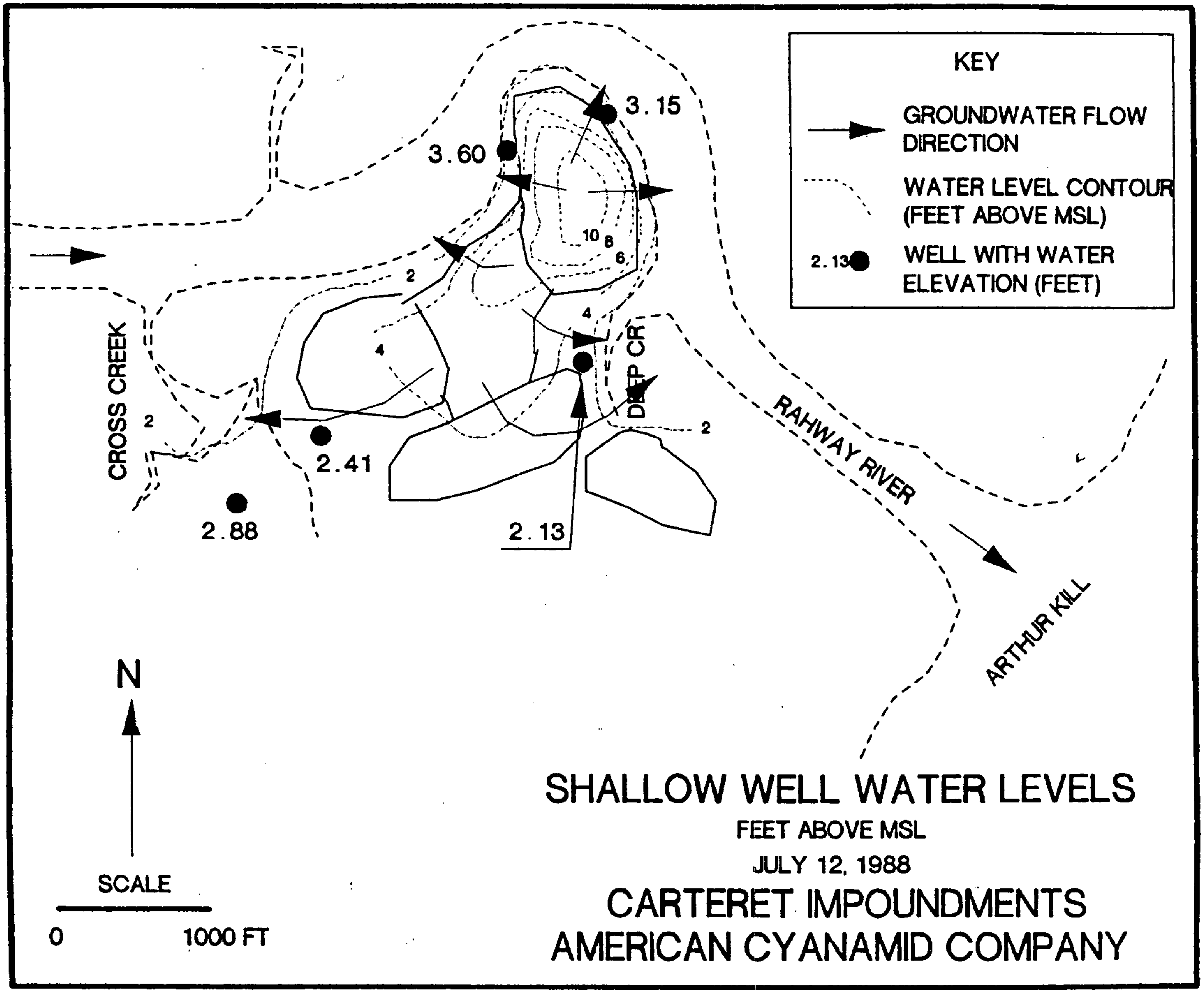

Figure 6. Generalized water table elevation contour map for the shallow aquifer showing groundwater flow directions (arrows).

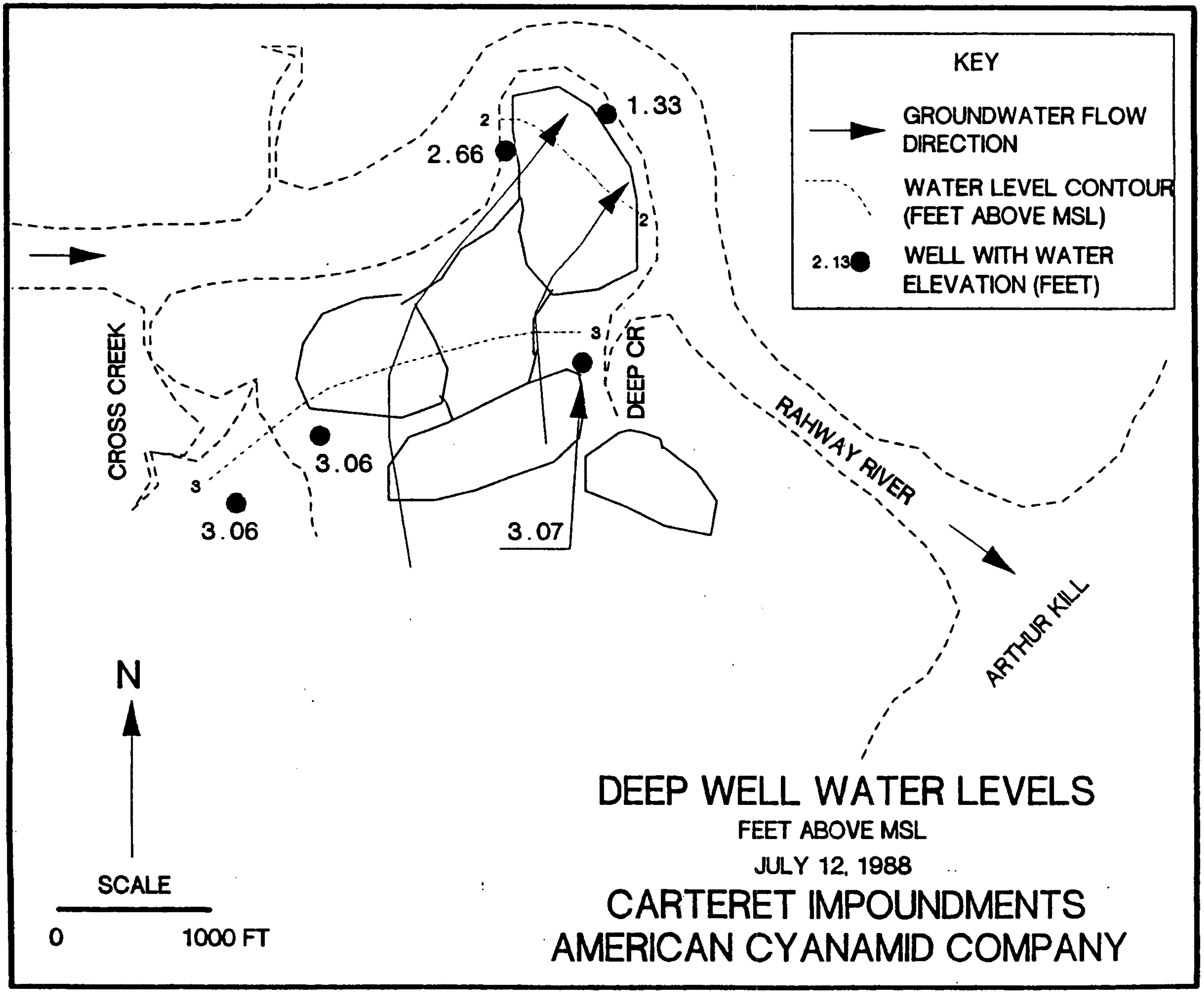

Figure 7. Generalized water table elevation contour map for the deep aquifer showing groundwater flow directions (arrows).

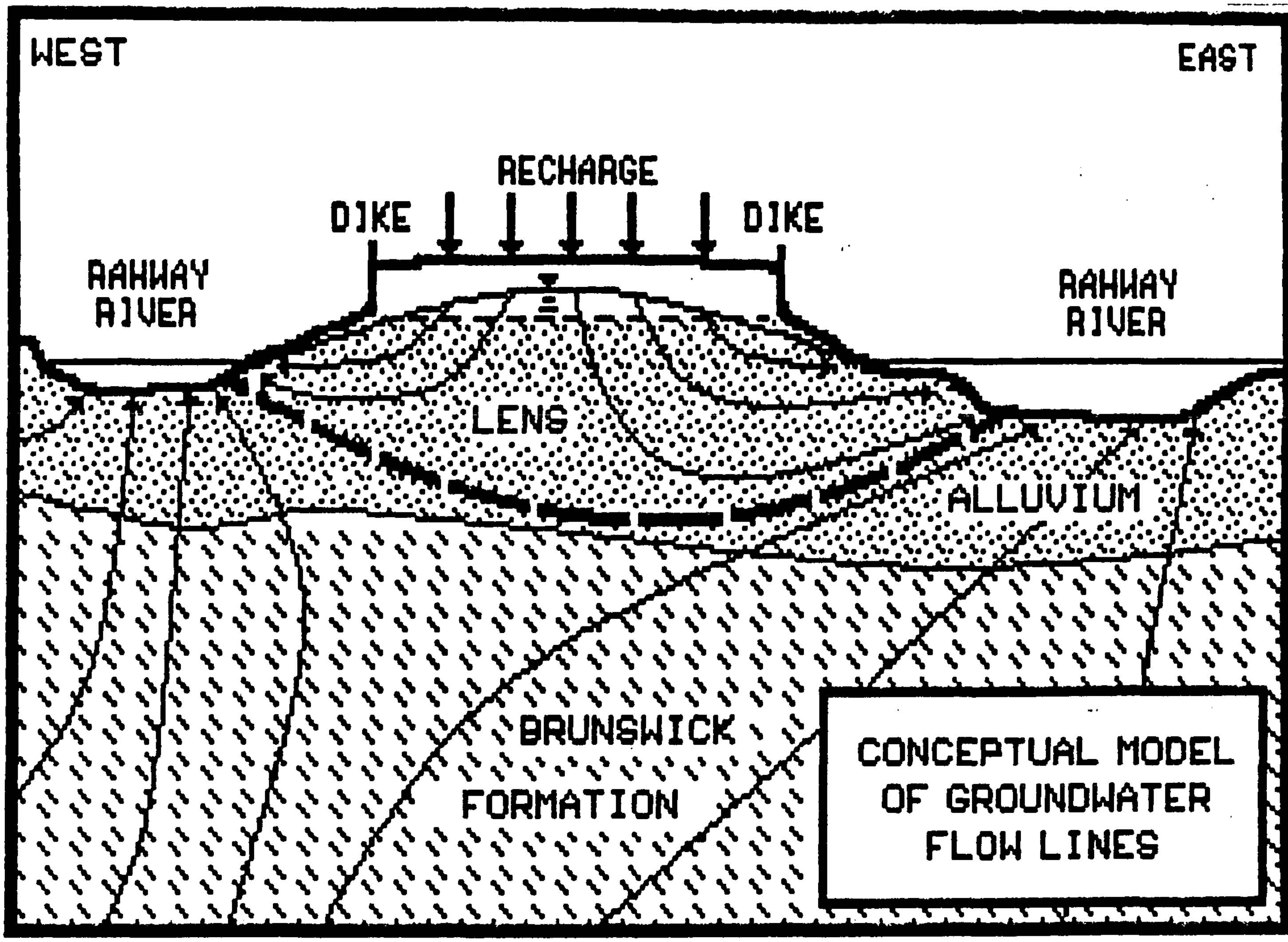

Figure 8. Generalized east-west cross-section beneath the Carteret impoundments showing the conceptualized groundwater flow system with a shallow flow system created by the mounded water table within the impoundments separated from a deeper groundwater flow system.

The combined effects of the site being in a groundwater discharge area, the presence of the confining clay, and the high density contrast between the leachate and groundwater results in the lateral and vertical hydraulic isolation of groundwater flowing from the impoundments.

3.6 Groundwater Flow Velocity

The velocity of groundwater flow out of the water table mound underlying the impoundments is estimated from the equation:

$$v = Ki/n$$

where v is groundwater pore velocity, K is the hydraulic conductivity, i is the gradient, and n is the effective porosity.

The maximum hydraulic gradient for the shallow aquifer is on the order of 10 feet over 1,000 feet, or 0.01 (measured on the water table contour map of Figure 6). For the sands and gravels, assuming a K of 3.8×10^{-3} cm/sec (10 ft/d) and an effective porosity of 0.1, groundwater velocity would be on the order of 0.33 meters per day (about 1.0 ft/d). For the clays, assuming a K of 2×10^{-6} cm/sec (0.006 ft/d) and an effective porosity of 0.05, groundwater velocity would be on the order of 0.03 meters per day (about 0.1 ft/d)

3.7 Hydrologic Budget

A hydrologic budget is used to estimate recharge to the groundwater through the impoundments by the following general equation:

Recharge = Precipitation - Runoff - Evapotranspiration

This equation is solved on a monthly basis using a modification of the U.S. Environmental Protection Agency method presented by Fenn et al. (1975) in which monthly runoff is estimated using the Soil Conservation Service runoff curve number method (Bureau of Reclamation, 1978), monthly evapotranspiration (ET) is estimated using the Thornthwaite method (described in Rosenberg et al., 1968), and monthly precipitation is obtained from climatic data.

A Lotus 1-2-3 spreadsheet program developed for this equation is presented in Appendix C.

Input requirements for the hydrologic budget analysis are:

Soil type (assumed to be similar to a silt),

Vegetation cover (two cases, 5% and 100% to represent before and after the vegetation project),

Surface area (100 acres),

Monthly precipitation,

Monthly mean temperature, and

Estimated monthly average antecedent

moisture content for upper one foot of soil (sludge in this case).

Soil type, vegetation cover, and antecedent moisture content are used to select the appropriate runoff curve number for each month. The estimated monthly runoff is then estimated based on the monthly curve number and the monthly precipitation as a percent of precipitation.

The results of this analysis provide the following estimated hydrologic budget for the Carteret impoundments:

Actual ET = 22 inches per year,

Runoff = 9 inches per year, and

Groundwater recharge (i.e., leachate production) =

17 inches per year for the 5% vegetated surface.

11 inches per year for the 100% vegetated surface.

Over the 100 acres of impoundment area, for the pre-vegetation case with 5% vegetated cover, 17 inches per year of recharge (i.e., leachate production), or 17,000 cubic feet per day (cfd), is predicted. For the post-vegetation case with 100% vegetated cover, 11 inches per year of recharge, or 11,000 cfd, is predicted.

4.0 GROUNDWATER EVALUATION

4.1 Groundwater Quality - Inorganic Constituents

Six sets of quarterly groundwater samples have been collected from the 10 monitoring wells from July 1987 through January 1989, although results are available only through the October 1988 quarterly event. Inorganic parameters including total and free cyanide and some metals are analyzed quarterly. Priority pollutant organics (volatiles, acid extractables, base-neutrals, and pesticides/PCBs) are analyzed annually. The full set of analytical data has been submitted to the NJDEP previously. Inorganic chemical data for each monitoring well are summarized in Tables 4 through 14. These data are compared to the State's GW/3 groundwater standards (second column in each table) for illustrative purposes. It should be emphasized that the natural TDS levels exceed the GW/3 criteria of 500-10,000 mg/l. Therefore, the local groundwater is more properly classified as GW/4, for which numerical standards are set on a case-by-case basis.

The data for the background wells, MW-1S and MW-1D, indicate no significant contamination migrating towards the background well location from the impoundments. The potential contaminants from the impounds, i.e., total cyanide, sodium, and sulfate, are at low, near background concentrations. The average total cyanide in MW-1S is below the GW/3 standard and below the detection limit in MW-1D samples. Sodium concentrations averaged 2,787 mg/l in MW-1S and 2,365 mg/l in MW-1D. Sulfate concentrations averaged 578 mg/l in MW-1S and 818 mg/l in MW-1D.

Iron, manganese, and ammonia concentrations are elevated above the GW/3 standards in the background well. Iron concentrations averaged 287 mg/l in MW-1S and 43 mg/l in MW-1D. Manganese concentrations averaged 7.2 mg/l in MW-1S and 6.7 mg/l in MW-1D. Ammonia was found to average 7.3 mg/l in the shallow well, and 0.8 mg/l in the deeper well. High iron and manganese concentrations are expected to occur naturally under the reducing conditions established in the highly organic shallow aquifer. Hem (1970, p. 124) states that strata containing oxidized iron minerals and organic debris may provide an environment favorable for reduction of ferric iron (the insoluble form) to ferrous iron (the soluble form) and give rise to rather high concentrations of dissolved iron. This scenario is supported by the considerable effervescence observed in the groundwater produced during development of MW-1S, which was probably caused by methane gas evolved by anaerobic bacteria living in the highly organic, oxygen deficient environment of the shallow aquifer.

TABLE 4. Summary of analyses for major inorganic constituents in groundwater samples for MW-1S.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	0.024		BDL				0.02
BARIUM	1.0		0.656		0.494				0.575
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	5830.	5780.	6530.	4400.	4350.	5250.	5357.
CHROMIUM, +6	0.05	0.026	BDL		BDL			0.005	
COPPER	1.0	0.01	BDL	0.019	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	0.348	0.059	0.057	0.103	0.178	0.216	0.2
CYANIDE-FREE		0.05		BDL	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	2.0		2.9				2.45
IRON	0.3	0.15	113.	717.	610.	62.1	101.	120.	287.
LEAD	0.05	0.005	BDL	0.03	BDL	BDL	0.0012	BDL	BDL
	0.005								
MANGANESE	0.05	0.005	3.5	14.	10.9	4.76	5.33	4.74	7.2
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	0.015						0.015
NITROGEN-AMMONIA	0.5	0.2	5.4	6.1	9.7	6.80	7.3	8.4	7.28
NITROGEN-NITRATE	10.0	1.0	0.2	BDL	INT	INT	BDL	BDL	0.05
pH	5-9		5.89	5.9	5.77	6.46	6.07	6.18	6.04
PHENOLS-TOTAL	3.5	0.05	0.59	1.98	0.44	INT	INT	0.88	0.89
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	2930.	4180.	3190.	2220.	2160.	2040.	2787.
SULFATE	BACKGROUND	5.0	310.	760.	990.	200.	590.	620.	578.
TDS	BACKGROUND	10.0	11900.	16600.	13900.	7900.	8800.	9490.	9800.
TOC		1.0	329.	762.5	226.	114.	397.	444.8	379.
TOX		0.5	1.36	1.75	5.52	1.3	0.372	0.975	1.7
ZINC	5.0	0.02	0.036	0.12	0.093	0.06	BDL	0.18	0.082

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 5. Summary of analyses for major inorganic constituents in groundwater samples for MW-1D.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	BDL		BDL				BDL
BARIUM	1.0		0.07		0.0940				0.082
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	9800.	9260.	9400.	9290.	9980.	9930.	9610.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.014	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CYANIDE-FREE		0.05		0.025	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	BDL		0.1				0.05
IRON	0.3	0.15	53.4	50.9	48.9	54.7	40.2	8.8	42.9
LEAD	0.05	0.005	BDL	0.0085	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	6.81	7.26	6.76	7.23	6.49	5.78	6.72
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	BDL	1.1		1.2	1.1	0.7	0.82
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	BDL	BDL		BDL
pH	5-9		6.6	6.03	6.12	6.36	6.31	6.64	6.34
PHENOLS-TOTAL	3.5	0.05	BDL	INT	INT	INT	BDL		BDL
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	2140.	2450.	2300.	2400.	2360.	2540.	2365.
SULFATE	BACKGROUND	5.0	800.	790.	800.	810.	840.	870.	818.
TDS	BACKGROUND	10.0	26600.	24900.	19700.	20600.		23700.	23100.
TOC		1.0	22.2	5.4	6.3	3.1	5.4	3.0	8.8
TOX		0.5	2.42	1.79	1.39	3.77	6.33	2.50	3.03
ZINC	5.0	0.02	0.037	0.048	0.037	0.087	BDL	0.068	0.046

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 6. Summary of analyses for major inorganic constituents in groundwater samples for MW-2S.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	0.04		0.09				0.065
BARIUM	1.0		0.034		0.018				0.026
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	9460.	9770.	8110.	7890.	9160.	8740.	8855.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.012	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	17.1	2.	41.		34.3	31.5	25.2
CYANIDE-FREE		0.05		0.034	BDL		BDL	0.2	0.058
FLUORIDE		0.1	4.		9.3				6.65
IRON	0.3	0.15	0.64	2.1	4.2	1.9	2.7	5.	2.76
LEAD	0.05	0.005	BDL	BDL	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	0.6	0.35	0.02	0.015	0.11	0.034	0.13
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	120.	170.		180.	170.	180.	164.
NITROGEN-NITRATE	10.0	1.0	0.2	BDL	BDL	BDL	BDL	BDL	BDL
pH	5-9		6.9	6.6	7.36	7.74	7.07	7.43	7.18
PHENOLS-TOTAL	3.5	0.05	BDL	1.09	0.354	BDL	BDL	BDL	0.241
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	5370.	5840.	4690.	4650.	5500.	5360.	5235.
SULFATE	BACKGROUND	5.0	2890.	3780.	12500.	2670.	2580.	3530.	4658.
TDS	BACKGROUND	10.0	20700.	22900.	18100.	17400.		20200.	19860.
TOC		1.0	29.1	18.3	25.	25.	23.7	44.2	27.5
TOX		0.5	1.77	2.46	7.82		2.88	2.95	3.58
ZINC	5.0	0.02	BDL	0.024	BDL	BDL	BDL	0.031	0.014

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 7. Summary of analyses for major inorganic constituents in groundwater samples for MW-2D.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	BDL		BDL				BDL
BARIUM	1.0		0.039		0.038				0.038
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	10100.	11000.	10900.	10000.	7470.	6950.	9403.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.012	BDL	0.013	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	1.16	0.071	BDL	3.3	7.6	2.43	2.43
CYANIDE-FREE		0.05		BDL	BDL	0.069	BDL	BDL	BDL
FLUORIDE		0.1	0.7		BDL				0.35
IRON	0.3	0.15	8.	17.	14.	1.4	BDL	1.2	6.9
LEAD	0.05	0.005	BDL	0.018	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	1.42	1.46	1.04	1.17	1.37	1.79	1.38
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	5.	2.8	2.8	5.5	51.	30.	16.2
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	BDL	BDL	BDL	BDL
pH	5-9			6.27	6.44		6.59		6.43
PHENOLS-TOTAL	3.5	0.05	0.25	INT	INT	INT	BDL	BDL	0.083
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	4900.	5450.	5280.	5060.	3860.	4750.	4883.
SULFATE	BACKGROUND	5.0	1000.	940.	880.	1070.	1530.	1310.	1122.
TDS	BACKGROUND	10.0	21900.	22900.	19420.	18900.		19600.	20544.
TOC		1.0	12.6	5.5	6.	8.4	17.5	14.1	10.7
TOX		0.5	1.46	0.695	5.81	0.426	3.45	2.15	2.33
ZINC	5.0	0.02	BDL	0.028	BDL	0.10	BDL	0.037	0.028

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 8. Summary of analyses for major inorganic constituents in groundwater samples for MW-3S.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	BDL		BDL				BDL
BARIUM	1.0		0.16		0.16				0.16
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	1180.	12000.	12500.	6230.	10300.	11130.	8890.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.01	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	BDL	BDL	BDL	0.422	0.458	BDL	0.147
CYANIDE-FREE		0.05		BDL	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	0.1		0.6				0.35
IRON	0.3	0.15	BDL	0.41	0.22	0.59	BDL	0.17	0.23
LEAD	0.05	0.005	BDL	0.017	BDL	BDL	BDL		BDL
MANGANESE	0.05	0.005	0.42	0.073	0.05	0.612	0.32	0.021	0.12
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	16.	36.	42.	21.	27.	30.	28.6
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		6.63	6.20	6.44	6.67	6.48	6.69	6.52
PHENOLS-TOTAL	3.5	0.05	0.505	INT	INT	INT	INT	BDL	0.25
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	5550.	6120.	6120.	4770.	5020.	5870.	5575.
SULFATE	BACKGROUND	5.0	110.	290.	44.	890.	400.	67.	300.
TDS	BACKGROUND	10.0	20900.	22200.	20400.	13100.	19000.	21600.	19533.
TOC		1.0	69.	43.	38.3	36.7	52.4	71.4	51.8
TOX		0.5	2.51	0.37	2.33	1.74	4.52	4.4	3.0
ZINC	5.0	0.02	0.025	BDL	BDL	BDL	BDL	BDL	BDL

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 9. Summary of analyses for major inorganic constituents in groundwater samples for MW-3D.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	BDL		BDL				BDL
BARIUM	1.0		0.093		0.080				0.087
CADMIUM	0.01	0.004	0.0047		BDL				BDL
CHLORIDE	BACKGROUND	1.0	7750.	11100.	11300.	12200.	10500.	11960.	10802.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.01	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	0.28	BDL	BDL	0.03	BDL	0.788	0.141
CYANIDE-FREE		0.05		BDL	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	1.2		0.6				0.9
IRON	0.3	0.15	1.4	17.	17.9	33.8	21.	9.6	16.8
LEAD	0.05	0.005	BDL	0.02	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	0.802	0.915	0.765	0.817	0.64	0.96	0.822
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	0.026						0.026
NITROGEN-AMMONIA	0.5	0.2	2.2	4.5	4.9	5.4	5.7	23.	7.62
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		6.80	6.82	6.48	6.6	6.57	6.67	6.66
PHENOLS-TOTAL	3.5	0.05	BDL	INT	INT	INT	BDL	BDL	BDL
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	3550.	5130.	5200.	5180.	5220.	5350.	4938.
SULFATE	BACKGROUND	5.0	940.	1090.	1090.	1150.	1160.	1650.	1180.
TDS	BACKGROUND	10.0	15100.	24800.	20900.	21900.		23400.	21220.
TOC		1.0	56.9	8.3	12.0	8.6	15.9	32.8	22.4
TOX		0.5	0.505	0.610	2.67	0.95	7.22	5.95	2.98
ZINC	5.0	0.02	0.038	0.025	0.028	BDL	BDL	0.066	0.026

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 10. Summary of analyses for major inorganic constituents in groundwater samples for MW-4S.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	0.033		BDL				0.016
BARIUM	1.0		0.026		0.028				0.027
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	16300.	16100.	17100.	15300.	14900.	13050.	15458.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.013	BDL	BDL	0.027	0.16	0.033
CYANIDE-TOTAL	0.2	0.025	106.	90.	100.	56.	112.	157.	103.5
CYANIDE-FREE		0.05		0.29	BDL	0.17	0.19	BDL	0.13
FLUORIDE		0.1	3.9		5.4				4.65
IRON	0.3	0.15	14.	17.	8.1	8.6	7.4	120.	29.2
LEAD	0.05	0.005	BDL	0.014	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	BDL	0.011	BDL	BDL	BDL	0.012	BDL
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	400.	510.	410.	380.	400.	360.	410.
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		8.72	8.87	8.89	8.98	8.6	8.25	8.72
PHENOLS-TOTAL	3.5	0.05	BDL	BDL	INT	INT	INT	BDL	BDL
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	8200.	8710.	9140.	8620.	8190.	7790.	8442.
SULFATE	BACKGROUND	5.0	3120.	3290.	3240.	2850.	2650.	4800.	3325.
TDS	BACKGROUND	10.0	28100.	29800.	27900.	27100.	27000.	27400.	27883.
TOC		1.0	119.	179.	127.	144.	133.9	116.1	136.5
TOX		0.5	1.4	0.49	3.02	2.28		4.9	2.42
ZINC	5.0	0.02	BDL	0.035	BDL	0.023	BDL	0.051	0.018

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 11. Summary of analyses for major inorganic constituents in groundwater samples for MW-4D.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	BDL		BDL				BDL
BARIUM	1.0		0.056		0.062				0.059
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	11600.	11600.	11300.	12200.	12300.	12200.	11867.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.012	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	0.7	0.18	0.535	0.302	0.363	0.632	0.54
CYANIDE-FREE		0.05		BDL	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	0.4		0.5				0.45
IRON	0.3	0.15	29.1	32.	20.	57.8	6.2	23.	28.02
LEAD	0.05	0.005	BDL	BDL	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	1.47	1.83	1.41	1.46	1.19	1.08	1.4
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	3.4	5.0	9.0	5.1	6.1	5.3	5.6
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		6.40	6.40	6.48	6.57	6.61	6.55	6.50
PHENOLS-TOTAL	3.5	0.05	BDL	INT	INT	INT	BDL	BDL	BDL
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	4140.	4290.	4410.	8970.	4990.	4730.	5255.
SULFATE	BACKGROUND	5.0	1180.	1160.	1090.	970.	1030.	1050.	1080.
TDS	BACKGROUND	10.0	25100.	26300.	22000.	24100.	25000.	25700.	24700.
TOC		1.0	21.4	12.2	9.3	9.7	14.0	12.1	13.1
TOX		0.5	1.56	0.57	3.21	1.06	9.98	0.85	2.87
ZINC	5.0	0.02	BDL	0.047	0.045	0.020	BDL	0.041	0.026

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 12. Summary of analyses for major inorganic constituents in groundwater samples for MW-5S.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	0.016		BDL				BDL
BARIUM	1.0		0.287		0.26				0.27
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	9790.	14500.	14900.	14500.	14100.	14470.	13710.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	0.012	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	4.05	BDL	6.1	6.96	4.76	3.4	4.21
CYANIDE-FREE		0.05		BDL	BDL	0.047	BDL	BDL	BDL
FLUORIDE		0.1	0.5		0.3				0.4
IRON	0.3	0.15	0.93	1.4	1.5	1.6	1.1	0.89	1.24
LEAD	0.05	0.005	BDL	BDL	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	0.33		0.033	0.025	0.0094	0.014	0.082
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	23.	31.	30.	28.	27.	21.	26.7
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		7.05	6.92	6.75	6.78	6.75	6.73	6.83
PHENOLS-TOTAL	3.5	0.05	0.39	BDL	INT	INT	BDL	BDL	0.10
SELENIUM	0.01	0.005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	6400.	7130.	7130.	7350.	7000.	7550.	7093.
SULFATE	BACKGROUND	5.0	130.	350.	250.	140.	210.	240.	220.
TDS	BACKGROUND	10.0	25000.	26300.	23900.	24000.	24400.	25300.	24817.
TOC		1.0	39.4	32.	31.1	28.9	280.2	37.6	74.9
TOX		0.5	1.22	3.66	6.28	4.06	4.3	4.4	3.9
ZINC	5.0	0.02	BDL	0.026	BDL	0.029	BDL	0.036	0.015

NOTE - CONCENTRATIONS IN MG/L.
BLANK = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

TABLE 13. Summary of analyses for major inorganic constituents in groundwater samples for MW-5D.

PARAMETER	GW/3 STANDARD	DETECTION LIMIT	DATE 7/31/87	10/20/87	1/19/88	4/12/88	7/12/88	10/14/88	AVERAGE
ARSENIC	0.05	0.01	0.01		BDL				BDL
BARIUM	1.0		0.251		0.27				0.26
CADMIUM	0.01	0.004	BDL		BDL				BDL
CHLORIDE	BACKGROUND	1.0	12100.	12000.	9120.	7810.	9600.	8400.	9838.
CHROMIUM, +6	0.05	0.026	BDL		BDL				BDL
COPPER	1.0	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
CYANIDE-TOTAL	0.2	0.025	2.56	4.5	10.6	12.2	25.6	9.45	10.8
CYANIDE-FREE		0.05		BDL	BDL	BDL	BDL	BDL	BDL
FLUORIDE		0.1	BDL		1.4				0.7
IRON	0.3	0.15	1.1	4.2	2.4	2.7	5.	2.7	3.02
LEAD	0.05	0.005	BDL	0.013	BDL	BDL	BDL	BDL	BDL
MANGANESE	0.05	0.005	1.55	1.72	0.606	0.439	0.19	0.27	0.80
MERCURY	0.002	0.0002	BDL	BDL	BDL	BDL	BDL	BDL	BDL
NICKEL		0.014	BDL						BDL
NITROGEN-AMMONIA	0.5	0.2	5.2	9.0	9.9	6.	10.	8.2	8.05
NITROGEN-NITRATE	10.0	1.0	BDL	BDL	BDL	INT	BDL	BDL	BDL
pH	5-9		7.15	6.52	7.01	6.62	7.12	7.83	7.04
PHENOLS-TOTAL	3.5	0.05	0.525	INT	INT	INT	BDL	BDL	0.18
SELENIUM	0.01	0 .005	BDL		BDL				BDL
SILVER	0.05	0.023	BDL		BDL				BDL
SODIUM	BACKGROUND	0.5	5460.	5690.	5000.	4260.	5210.	5110.	5122.
SULFATE	BACKGROUND	5.0	470.	670.	1410.	1580.	430.	670.	872.
TDS	BACKGROUND	10.0	21000.	23500.	17400.	15800.	17700.	16800.	18700.
TOC		1.0	26.	13.9	25.4	20.8	47.2	55.6	31.5
TOX		0.5	1.11	0.99	2.97	3.62	2.53	1.18	2.06
ZINC	5.0	0.02	BDL	0.025	BDL	0.056	BDL	BDL	BDL

NOTE - CONCENTRATIONS IN MG/L.
BLANK SPACE = NOT ANALYZED
BDL = BELOW DETECTION LIMIT
INT = INTERFERENCE, INDETERMINANT

Significant concentrations of total cyanide (free and complexed cyanide dissolved species) were detected in shallow wells MW-2S, MW-4S and MW-5S at average values of 25 mg/l, 103 mg/l and 4.2 mg/l, respectively. Nitrogen-ammonia (ammonia) concentrations in MW-2S, 4S, and 5S are elevated above background with average values of 164, 410, 26.7 mg/l, respectively. Sodium concentrations are elevated by a factor of approximately two over the background well MW-1S average of 2,787 mg/l with averages of 5,235 mg/l in MW-2S, 8,442 mg/l in MW-4S, and 7,093 mg/l in MW-5S. Sulfate concentrations are elevated by a factor of approximately five to ten over the background average of 578 mg/l in MW-1S with averages of 4,658 mg/l in MW-2S, 3,325 mg/l in MW-4S. However, in MW-5S, the sulfate concentration has averaged only 220 mg/l, which is only about one-third the background value.

In contrast to the other wells, shallow well MW-3S samples had an average total cyanide concentration of only 0.15 mg/l, well below the GW/3 standard, and an average sulfate concentration one-half the background value with an average of 300 mg/l. Ammonia averaged 28.6 mg/l, which was above background, but below the averages for MW-2S and 4S. Sodium levels in MW-3S are elevated above the background levels in MW-1S, with an average of 5,575 mg/l versus 2,787 mg/l in MW-1S.

All other inorganic constituents in wells MW-2S, 3S, 4S, and 5S were found to be below the detection limits or near the concentrations in the background well.

The high levels of ammonia, especially in MW-2S and 4S, are believed to be the result of the degradation of cyanide, possibly due to bacterial processes. This interpretation is supported by a regression of ammonia versus cyanide, shown in Table 14 and Figure 9, for the average concentrations in all shallow wells. This regression analysis indicates that 98.7% of the variance of the average ammonia concentration is accounted for by the variance of the average total cyanide concentration.

In summary, the inorganic data supports the conclusion that MW-1S is a background well virtually unaffected by the impoundments. Wells MW-2S, 4S, and 5S appear to be affected by leachate from the impoundments with elevated total cyanide, ammonia, sulfate, and sodium. MW-3S, initially expected to produce contaminated groundwater, has, in contrast to MW-2S, 4S, and 5S, produced samples with very low total cyanide, no detectable free cyanide, relatively low ammonia, and below background levels for sulfate, although sodium is somewhat elevated.

For the deep monitoring wells, only MW-5D samples were reported to have significant levels of total cyanide with an average of 10.8 mg/l. These cyanide levels are similar to those reported for MW-5S which averaged 4.2 mg/l. It should be recalled that MW-5D is screened at a shallower interval than the other deep wells and is screened in the same geologic formation as MW-5S. Thus, MW-5S and 5D could be expected to produce groundwater samples with more similar chemical characteristics.

Well MW-4D samples had an average total cyanide concentration of 0.54 mg/l, only slightly above the GS/3 standard of 0.2 mg/l. No other inorganic constituents in deep well samples are significantly above concentrations in the background well MW-1D.

TABLE 14. Regression analysis for the average concentrations of ammonia versus total cyanide in well samples.

WELL	TOTAL CYANIDE (MG/L)	AMMONIA (MG/L)	REGRESSION LINE
1S	0.16	7.28	23.5
3S	0.15	28.70	23.5
5S	4.20	26.70	39.0
2S	28.70	164.00	132.5
4S	103.50	410.00	418.2

Regression Analysis:

Constant	22.9
Standard Error of Y Estimate	22.4
R Squared	0.987
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s)	3.819
Standard Error of Coefficient	0.253

Regression Equation: $[NH_4^{-2}] = 3.819 \times [CN^-] + 22.9$

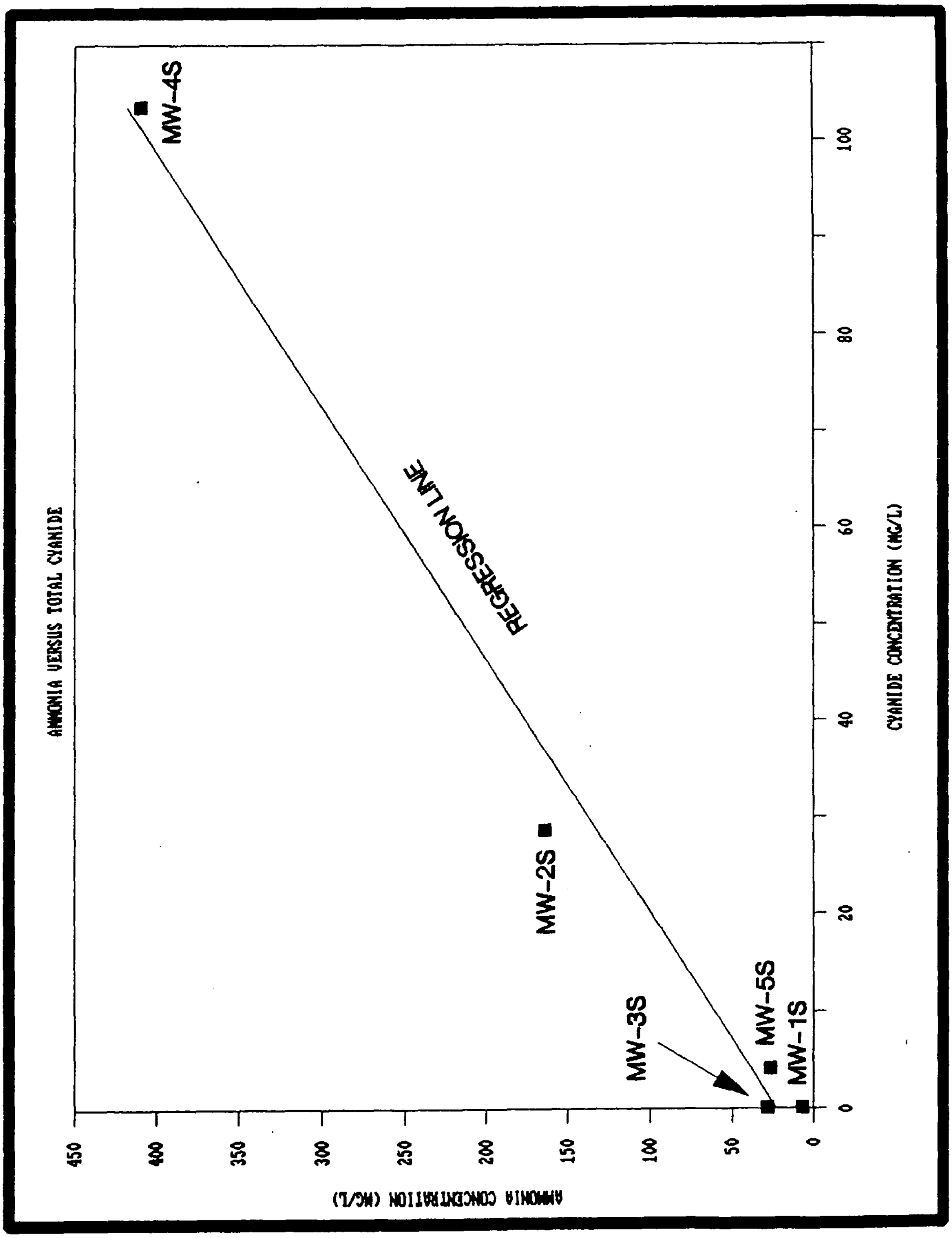

Figure 9. Plot of the regression of average concentrations of ammonia versus total cyanide concentrations in well samples.

In summary, contamination from the impoundments is not migrating to a significant depth, but is remaining in the shallow zone above a depth of 50 feet.

4.2 Groundwater Quality - Organic Constituents

Results of organic analyses of the groundwater samples demonstrate that there is no organic contamination migrating from the impoundments. The results for wells MW-2S, MW-3S, MW-4S, and MW-5S show no consistently detectable levels of priority pollutant volatiles, acid extractables, base/neutral extractables, or pesticides/PCBs.

Analytical results for MW-1S, the background well, indicate the presence of numerous priority pollutant organic compounds. Table 9 summarizes the organic constituents detected in MW-1S.

American Cyanamid's Carteret impoundments are located in a highly industrialized area. The Site is surrounded by petroleum product storage tank farms, the Township of Carteret owns a closed sanitary landfill west of the impoundments, and a private "salvage" yard has operated for a number of years adjacent to the impoundments on the west. Cyanamid found the salvage operations had encroached on to Cyanamid's property in the vicinity of MW-1 at the time the monitoring well locations were initially determined.

Prior to installation of MW-1S and 1D, the salvage material was removed from Cyanamid's property. This material included an inoperable truck and semi-trailer, metal pipe, two steel tanks of approximately 20,000-gallon capacity, and miscellaneous trash. The organic contamination found at MW-1S is limited to the shallow zone and suspected to originate from the adjacent properties.

Low levels of phenol were detected in samples for the July 31, 1987 event from MW-3S and MW-4S at concentrations of 4.92 ug/l and 22.5 ug/l, respectively. The origin of these trace levels of phenol is unknown as phenol was not a constituent of the inorganic process wastes deposited in the impoundments.

Ethylbenzene and toluene were detected in the MW-5D January 19, 1988 sample at concentrations of 70.4 ug/l and 21.4 ug/l, respectively. The origin of these two compounds which were previously undetected in this well is unknown since neither of these were constituents of the inorganic process wastes deposited in the impoundments. These petroleum related compounds may originate at the adjacent properties.

TABLE 15. Summary of analyses for organic constituents in groundwater samples for MW-1S.

PARAMETER	DETECTION LIMIT	MW-1S 7/31/87	1/19/88	TRIP BLANK 7/31/87
PRIORITY POLLUTANT VOLATILES				
BENZENE	4.4	195.	207.	BDL
CHLOROBENZENE	6.0	18.2	34.	BDL
CHLOROFORM	1.6	BDL	8.11	BDL
1,1-DICHLOROETHANE	4.7	65.5	127.	BDL
1,1-DICHLOROETHYLENE	2.8	19.	23.7	BDL
ETHYLBENZENE	7.2	21.9	29.9	BDL
METHYLENE CHLORIDE	2.8	BDL	150.	15.5
TOLUENE	6.0	2940.	4340.	BDL
1,1,1-TRICHLOROETHANE	3.8	18.4	67.3	BDL
TRICHLOROETHYLENE	1.9	83.5	98.3	BDL
VINYL CHLORIDE	10.0	12.3	19.9	BDL
CHLOROETHANE	10.0	45.1	36.	BDL
1,2-TRANS-DICHLOROETHYLENE	1.6	72.6	86.7	BDL
PRIORITY POLLUTANT ACID EXTRACTABLE				
2-CHLOROPHENOL	3.4	9.72	BDL	BDL
2,4-DICHLOROPHENOL	2.8	3.43	BDL	BDL
2,4-DIMETHYLPHENOL	2.8	3.77	BDL	BDL
PHENOL	1.5	66.8	376.	BDL
PRIORITY POLLUTANT BASE/NEUTRAL EXTRACTABLE				
ISOPHORONE	2.2	168.	BDL	BDL
NAPHTHALENE	1.6	5.65	BDL	BDL
NITROBENZENE	1.9	28.8	BDL	BDL

NOTE - ALL CONCENTRATIONS IN UG/L.
BDL = BELOW DETECTION LIMIT

4.3 Potential Groundwater Receptors

The Brunswick Formation is not known to be used as a source of groundwater for consumptive purposes in the vicinity of the Site. The closest water supply well to the impoundments is 4,000 feet southwest and upgradient of the Site near the intersection of Roosevelt Avenue and the New Jersey Turnpike. This well, reported by Disko (1981) to be owned by Gulf Stream Development, has a reported yield of 100 gpm which is too low to cause a reversal in groundwater flow at the distance of the impoundments. Even in areas where the Brunswick is used as a source of water, the groundwater has been reported to be locally high in sulfate and hardness due to the presence of evaporite deposits, i.e., gypsum and salt (Disko, 1982). In the vicinity of the Carteret impoundments, the high salinity of the groundwater precludes the use of the Brunswick Formation as a source of groundwater.

Based on the information gathered concerning the groundwater flow system at the Site, no water supply wells producing from the Brunswick Formation can draw groundwater that originates in the impoundments. The survey of groundwater usage conducted by Disko (1982) indicates that no water supply wells are located downgradient of the impoundments.

5.0 SURFACE WATER EVALATION

5.1 Surface Water System

The Carteret impoundments are in the Rahway River drainage basin, located from 0.5 and 1.0 miles upstream of the confluence with the Arthur Kill. The impoundments are bordered on the north and east by the Rahway, on the west by a small tributary to the Rahway named Cross Creek, and on the south and east by another small tributary to the Rahway called Deep Creek (shown in Figure 1). These surface waters are tidal with average tidal variations on the order of four feet.

5.2 Surface Water Flow

The flow of the Rahway River has been monitored by the U.S. Geological Survey at Rahway, New Jersey. For the water years 1922-1984, the average flow of the Rahway was 47.5 cubic feet per second (U.S. Geological Survey, 1983).

5.3 Surface Water Quality

A theoretical worst-case calculation for free cyanide concentration in the Rahway River has been performed to assess the impact of the leachate on surface waters. The following conditions were utilized in a simple dilution calculation:

1. The highest concentration of free cyanide detected in the groundwater (0.29 mg/l),

2. 11,000 to 17,000 cfd flow of groundwater into the Rahway River, and

3. An average flow in the Rahway River of 47.5 cfs.

Based on these worst case values, free cyanide concentrations in the Rahway should range from 0.8 to 1.2 ug/l (ppb).

To confirm the absence of an impact on the Rahway River, a comprehensive surface water study was conducted in October 1986. Figure 10 shows the locations of the surface water sampling points in the Rahway River upstream and downstream of the impoundments, in Cross Creek, and in Marsh Creek opposite the impoundments. The upstream and downstream stations in the Rahway River consisted of three stations at each location providing samples one-quarter, one-half, and three-quarters across the channel. At each station, the sample was collected from a four-foot interval centered on the mid-depth. In water less than four feet deep, the sample represented the full column of water. Each station was sampled twice, at high (except stations 7 and 8 in the creeks) and low tides. Appendix D presents the laboratory reports for the surface water analyses for total and free cyanide.

The results of the river sampling program indicate that both total and free cyanide were below the detection limit of 0.025 mg/l in all samples for the Rahway River and Marsh Creek opposite the impoundments. The sample collected in the mouth of Cross Creek was reported to have 0.032 mg/l of total cyanide and 0.032 mg/l of free cyanide. These results are consistent with the theoretical calculations presented above.

5.4 Potential Surface Water Receptors

No surface water intakes for drinking water are known downstream of the impoundments. The Rahway River and its tributaries in the vicinity of the impoundments are brackish with observed salinities of 15 parts per thousand.

6.0 FATE OF CYANIDE IN SURFACE WATER AND GROUNDWATER

The fate of cyanide released in leachate leaving the Carteret impoundments is dominated by three processes: dilution, volatilization, and biodegradation. These processes operate to reduce the concentration of both total and free cyanide in water as it migrates from the impoundments.

Callahan et al. (1979) report that in water with a pH less than 7, over 99% of the free cyanide will be in the form HCN (hydrogen cyanide), which is highly volatile. Therefore, the free cyanide tends to volatilize and decrease the concentration of total cyanide as the equilibrium between complexed and free cyanide shifts towards the free cyanide. EPA (1986) reported a half-life of between 0.33 and 0.80 days in surface water.

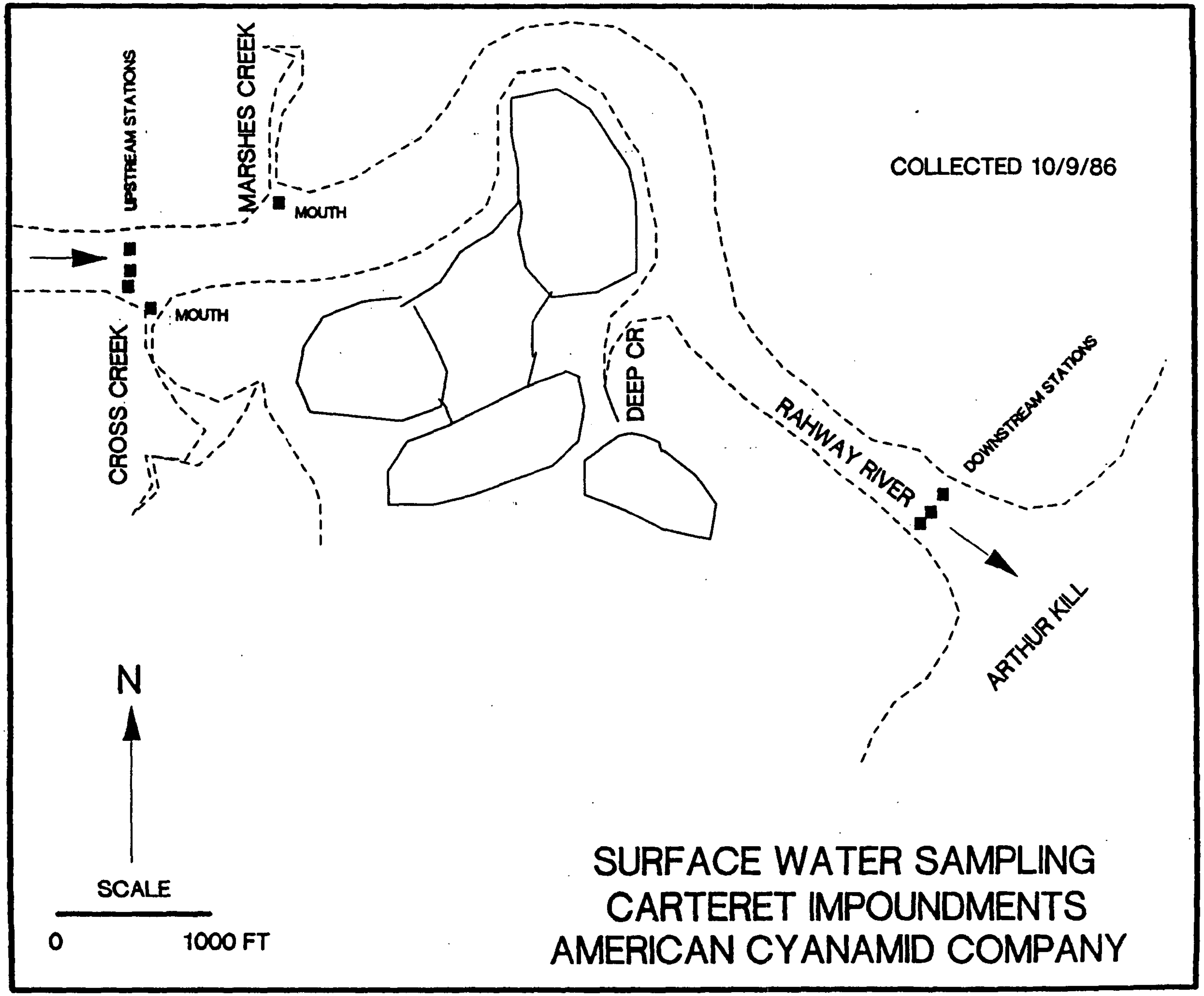

Figure 10. Locations of surface water sampling stations for the October 1986 study.

Callahan et al. (1979) also report that biodegradation of cyanide occurs in all organisms where the cyanide concentration is below toxic levels. They report virtually complete degradation of cyanide occurs in anaerobic and aerobic sewage treatment. Callahan et al. (1979) cite experiments which indicate the biodegradation of hydrogen cyanide produces methane and ammonia under reducing conditions. The high concentrations of ammonia found in the groundwater samples downgradient of the impoundments and the high correlation between the ammonia and total cyanide, as discussed earlier, provides evidence that anaerobic biodegradation in the subsurface may be an important degradation process.

7.0 HUMAN HEALTH AND ENVIRONMENTAL ASSESSMENT

7.1 Human Health Assessment

Based on the results of the sludge, groundwater, and surface water analyses, the constituent of concern being released from the impoundments is cyanide. Since no surface water or groundwater sources of drinking water are downgradient or capable of disturbing the local groundwater flow system or of drawing water that originates in the impoundments, there are no potential risks to human health via drinking water.

Since the impoundments are inaccessible to unauthorized persons, risks to human health via direct contact are negligible.

7.2 Environmental Assessment

The standards promulgated under the New Jersey Pollutant Discharge Elimination System (NJPDES) establishe a water-quality criteria of 0.03 mg/l free cyanide for protection of aquatic life in salt water (Title 7, Chapter 14, section 7:14a, Appendix F, <u>Values for Determination of NJPDES Permit Toxic Effluent Limits</u>).

The results of the surface water analyses discussed in section 5.3 indicate that the Rahway River adjacent and downstream of the impoundments achieves the NJPDES standard of 0.03 mg/l free cyanide.

8.0 CONCLUSIONS AND IMPLICATIONS

8.1 Hydrogeology

Migration of potential contaminants originating in the impoundments are confined to a limited volume of the shallow aquifer immediately below the impoundments. The upward flow of groundwater out of the Brunswick Formation and the density contrast between the relatively lighter leachate and the denser natural groundwater combine to create a floating lens of leachate on the natural groundwater.

The impoundments receive recharge from precipitation which creates a mounded water table beneath the impoundments. The water table mound is within the sludge of the impoundments at a minimum depth of about five feet in the central part of the impoundments. The shallow groundwater flows radially outward from the groundwater mound and discharges into the surrounding surface water, i.e., the Rahway River on the north, Cross Creek on the west, and Deep Run Creek on the south and east.

Deep groundwater within the Brunswick Formation is flowing out of the Brunswick into the shallow groundwater and also is discharging to surface water. The groundwater mound within the impoundments has not created a significant downward vertical flow component into the Brunswick Formation. Thus, the leachate does not penetrate vertically into the aquifer more than 50 feet.
This has been substantiated by the lack of significant contamination in the deeper wells that are screened at approximately 50 feet below the surface.

8.2 Groundwater Quality

The results of the quarterly groundwater monitoring indicate the impoundments are contributing contamination to the shallow groundwater system, that is, groundwater in the zone overlying the Brunswick Formation. The contaminants migrating from the impoundments are total cyanide, ammonia, sulfate, and possibly sodium. Due to the shallow vertical extent of migration of groundwater from the impoundments, the deep monitoring well data indicate the contamination from the impoundments is contained within the shallow zone within the upper 50 feet.

8.3 Surface Water Quality

Analyses of surface water samples collected in the Rahway River both upstream and downstream of the impoundments indicates no detectable cyanide is present (detection limit of 0.025 mg/l). The lack of detectable cyanide in the river samples and results of literature research concerning the fate of cyanide in the aquatic environment support the conclusion that the impoundments have no significant impact on the Rahway River.

Results of analyses of surface water samples collected in the mouth of Cross Creek where it enters the Rahway River (0.032 mg/l free cyanide) indicate that, although low levels of cyanide are entering Cross Creek via groundwater discharge, the levels appear to be at or below the NJPDES surface water quality criteria of 0.03 mg/l free cyanide.

8.4 Appropriate Groundwater Quality Standards

Currently, groundwater in the shallow aquifer and in the Brunswick Formation in the vicinity of the Site is not used for drinking water. Considering the naturally high salinity and iron content of the groundwater, it is unlikely that this groundwater would be used in the foreseeable future. In addition, although the Brunswick Formation is used as a source of water upgradient of the Site, there are no existing wells capable of reversing groundwater gradients to capture groundwater underlying the impoundments.

In consideration of the low risk presented by the impoundments and the fact that the NJDEP is currently considering substantial revisions to the State Ground Water Quality Standards, it is suggested that the determination of a groundwater standard applicable to the Carteret Impoundments be deferred.

8.5 Need for Corrective Action

During 1989, the revegetation of the surface of the Carteret Impoundments will be completed. During the growing season, the fully revegetated impoundment surface will substantially reduce the recharge of groundwater underlying the impoundments due to the increase of evapotranspiration. The reduction in generation of leachate will further reduce the any impact presented by the impoundments. No additional corrective actions are required at this time.

8.6 Future Work

Monitoring at the Carteret Impoundments should be continued to confirm the conclusions of this assessment. However, it is recommended that the inorganic water quality parameters be reduced to field pH, total cyanide, ammonia, and sulfate in all wells on a semiannual basis.

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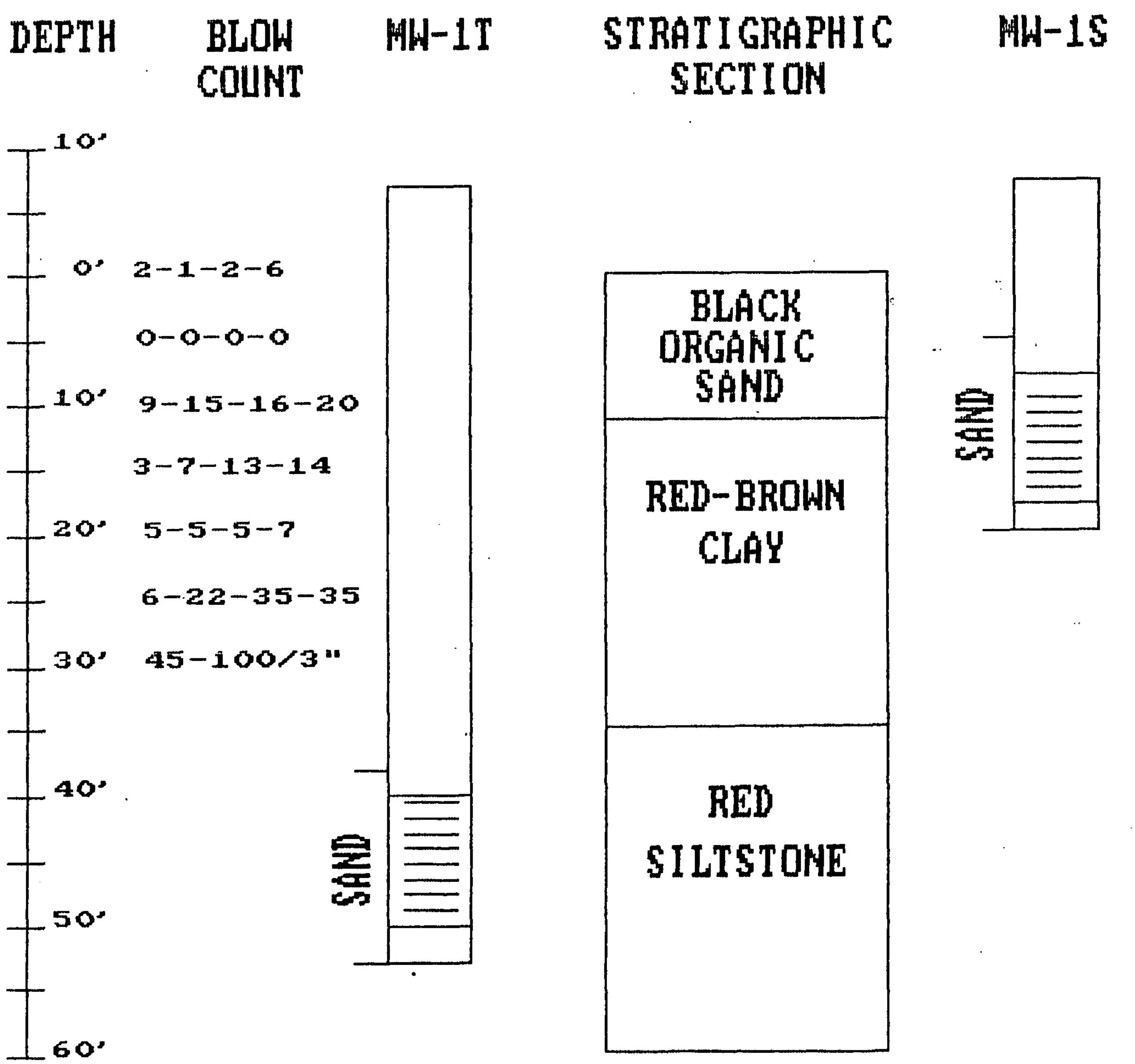
APPENDIX A

Monitoring Well Construction Diagrams
Geologic Logs
State of New Jersey Permit to Drill
Monitoring Well Certification, Form A

MONITORING WELL DESCRIPTION
GEOLOGIC LOG

DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: MAY 3 AND JULY 6, 1987
LOGGED BY: PAUL FERRE' AND JOHN BUCKLEY



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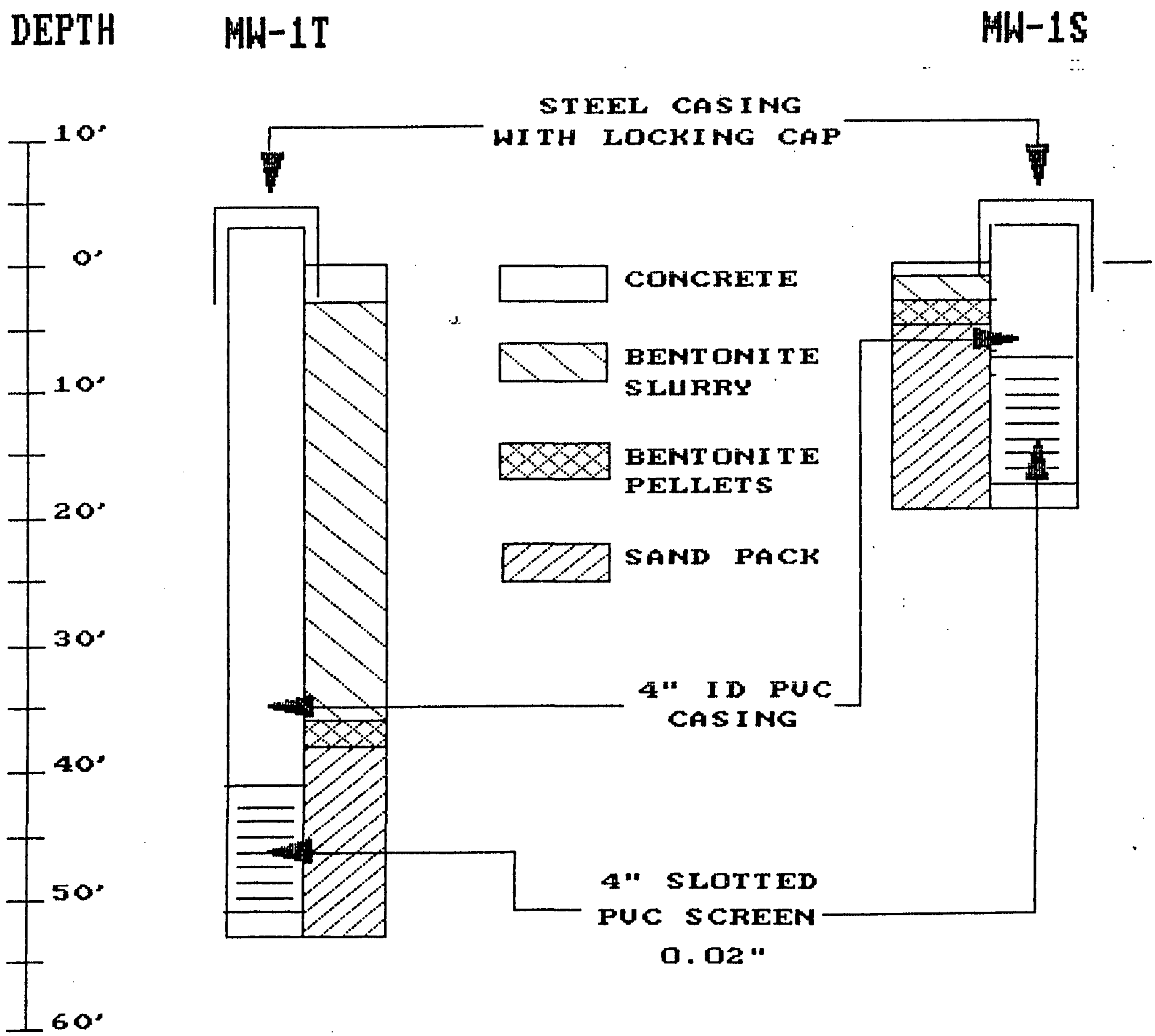
MONITORING WELL DESCRIPTION
AS BUILT DRAWING

DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: MAY 3 AND JULY 6, 1987



MONITORING WELL DESCRIPTION

GEOLOGIC LOG

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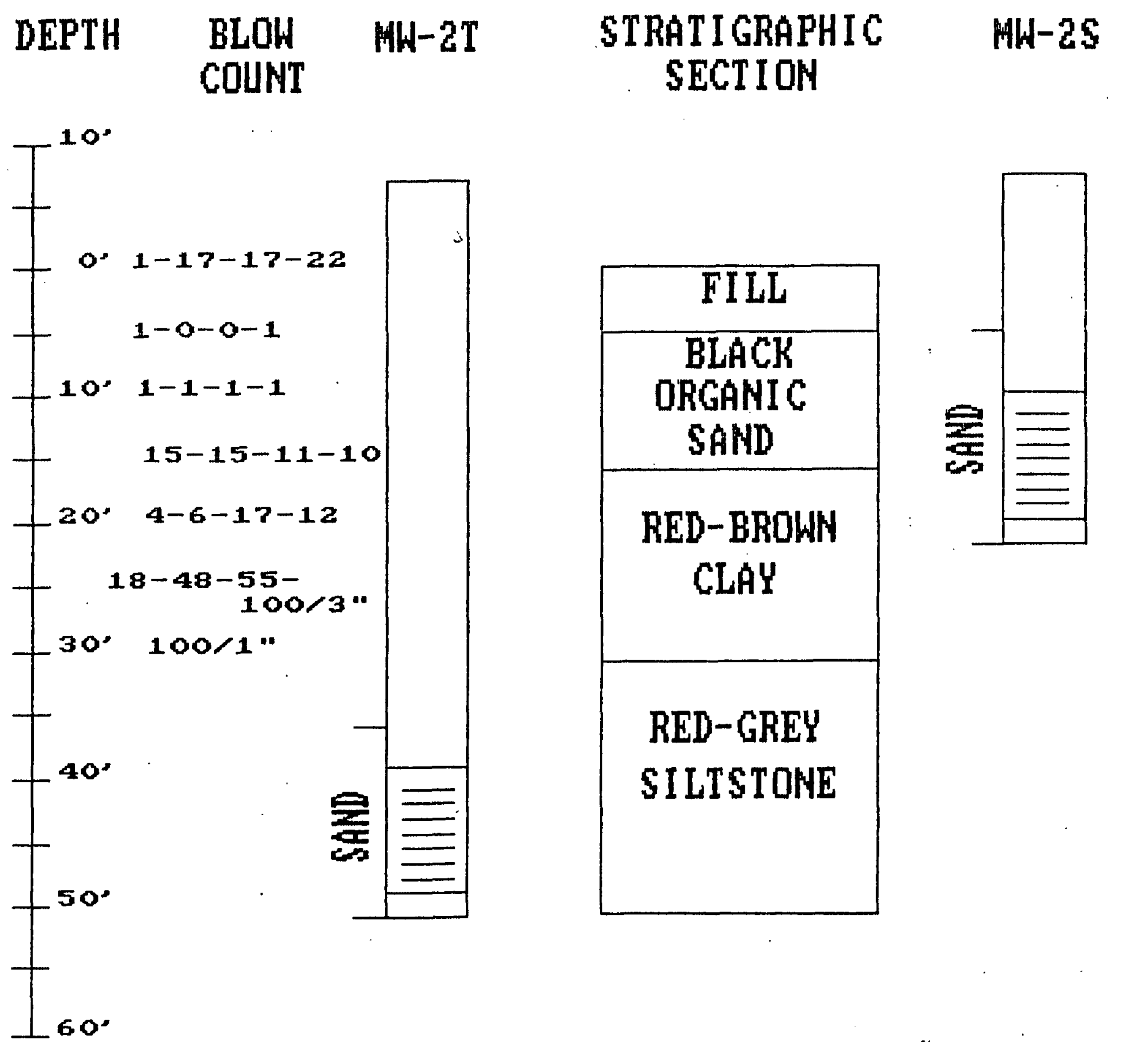

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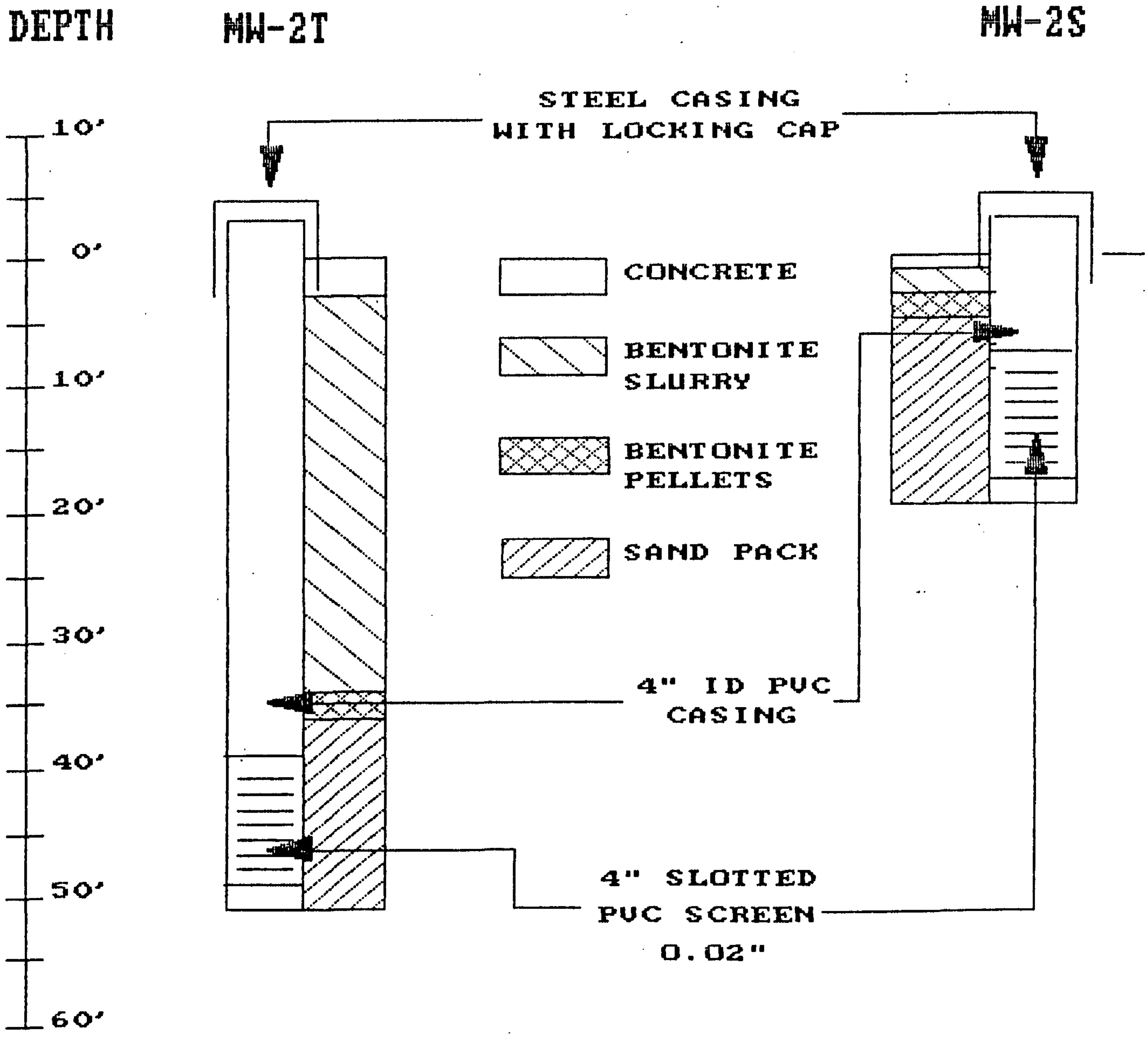

MONITORING WELL DESCRIPTION
GEOLOGIC LOG

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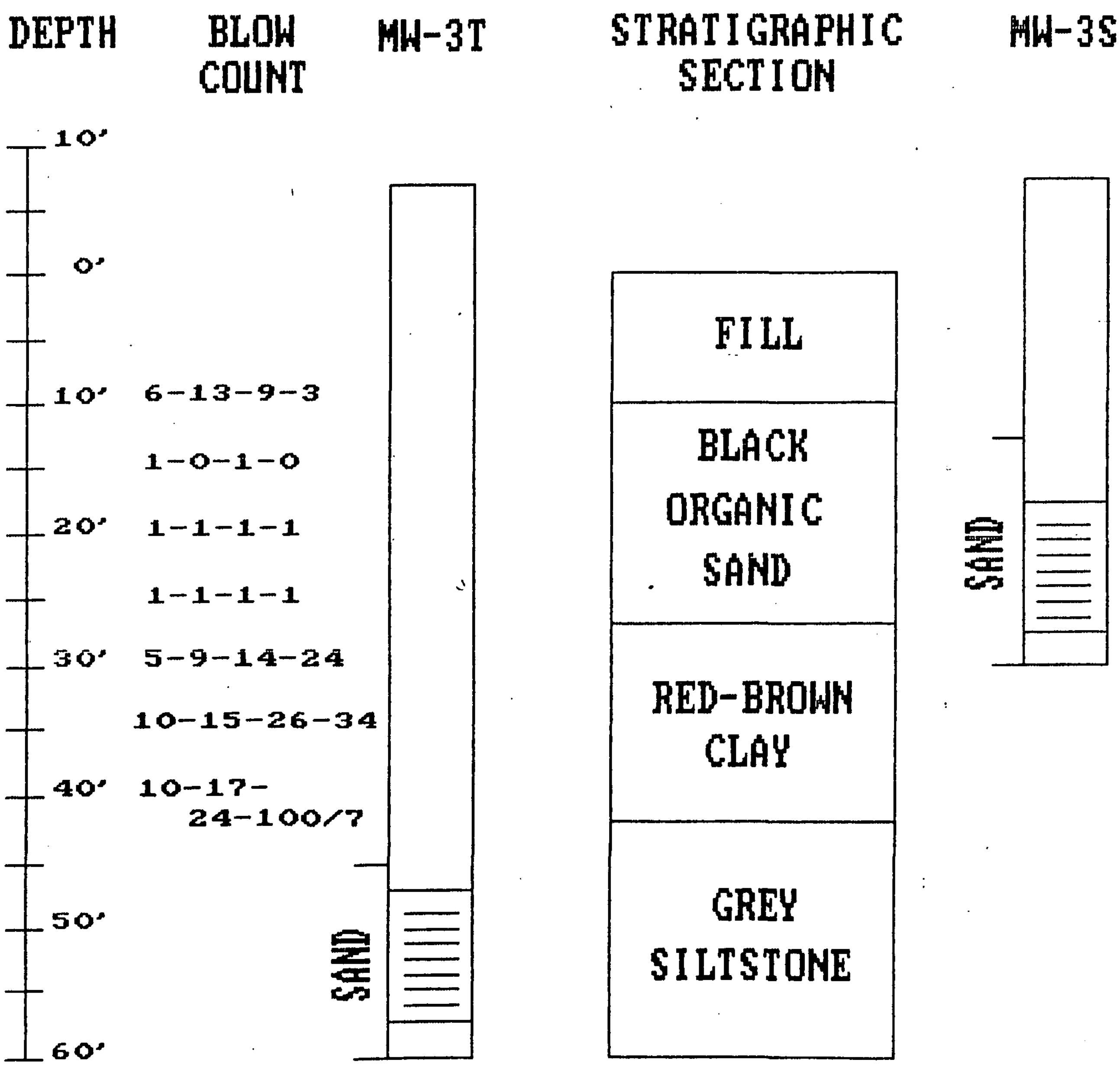
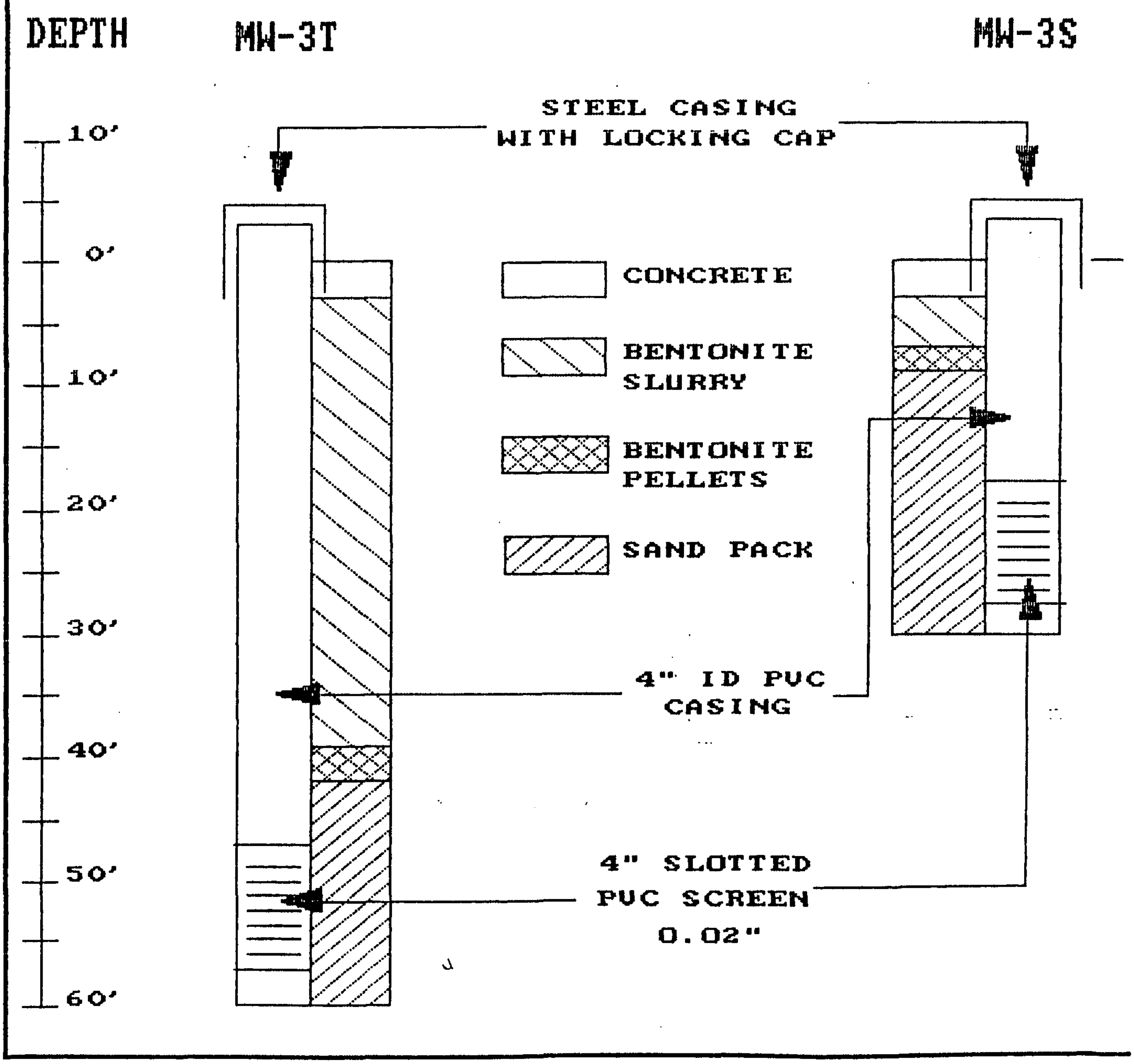
DATE DRILLED: JULY 28, 1987
LOGGED BY: PAUL FERRE'



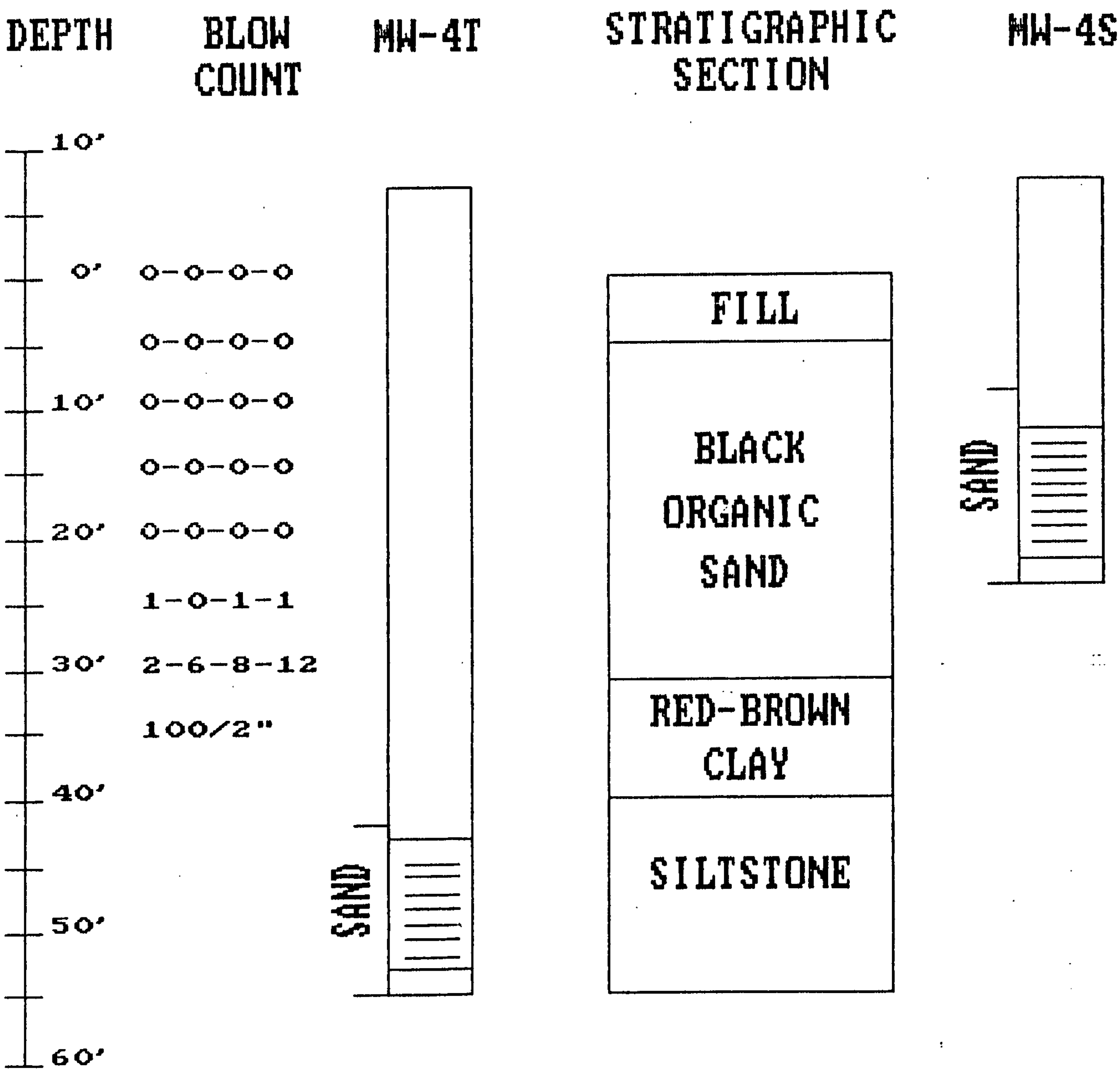
MONITORING WELL DESCRIPTION
AS BUILT DRAWING

DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: JULY 28, 1987



MONITORING WELL DESCRIPTION
GEOLOGIC LOG

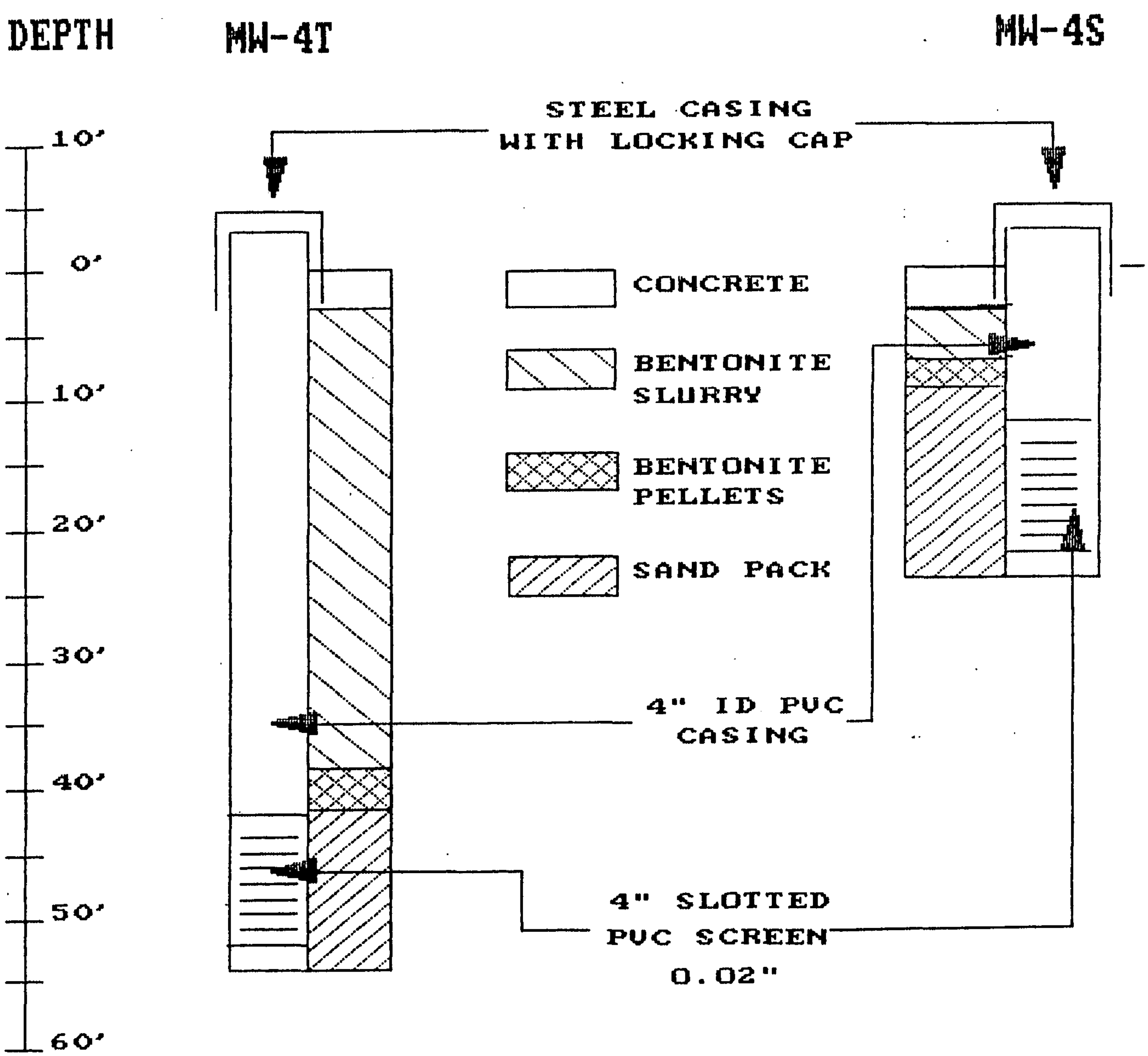
DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: JULY 24, 1987
LOGGED BY: JOHN BUCKLEY



MONITORING WELL DESCRIPTION
AS BUILT DRAWING

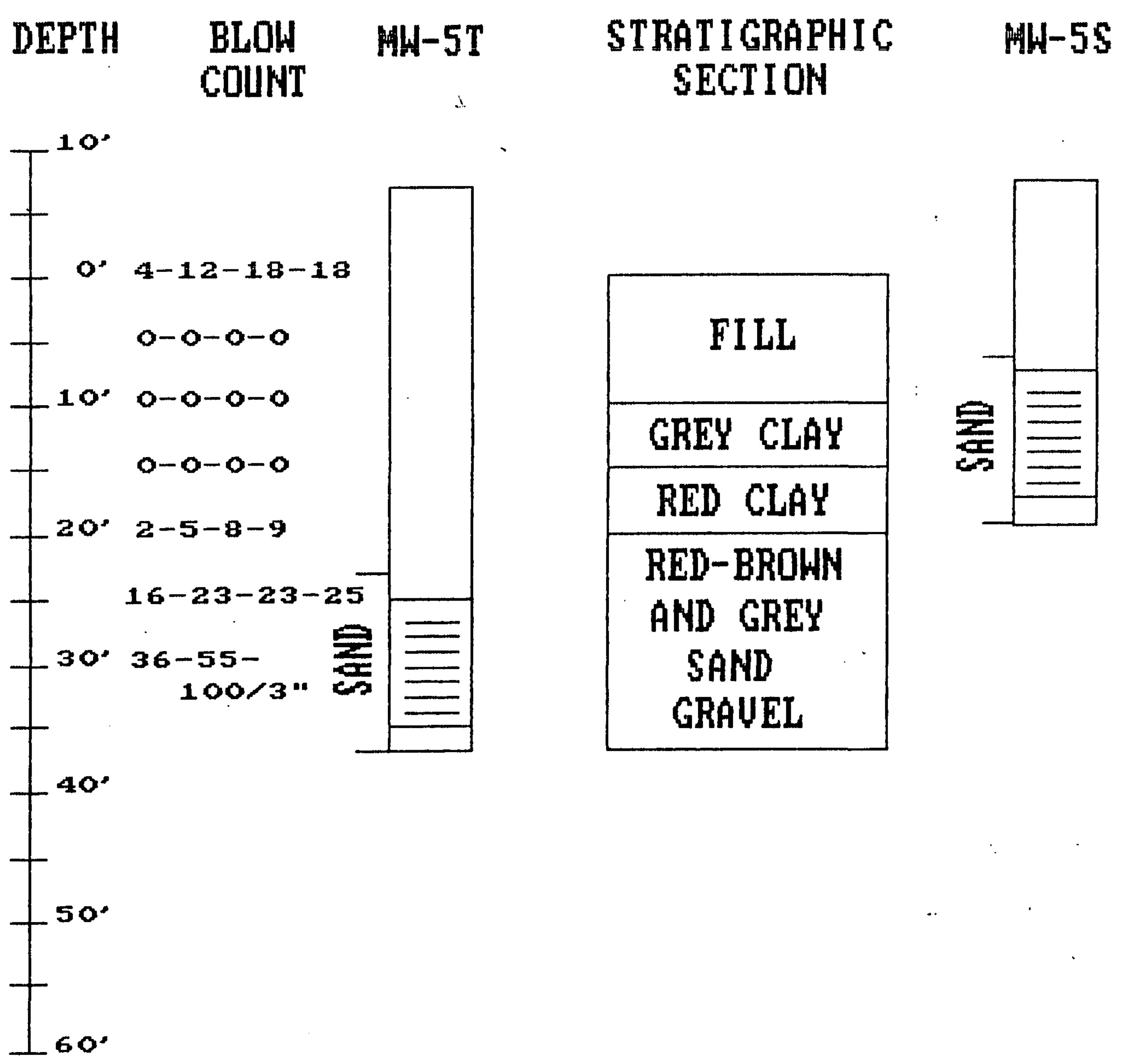
DRILLER: TESTWELL CRAIG TEST BORING

DATE DRILLED: JULY 24, 1987



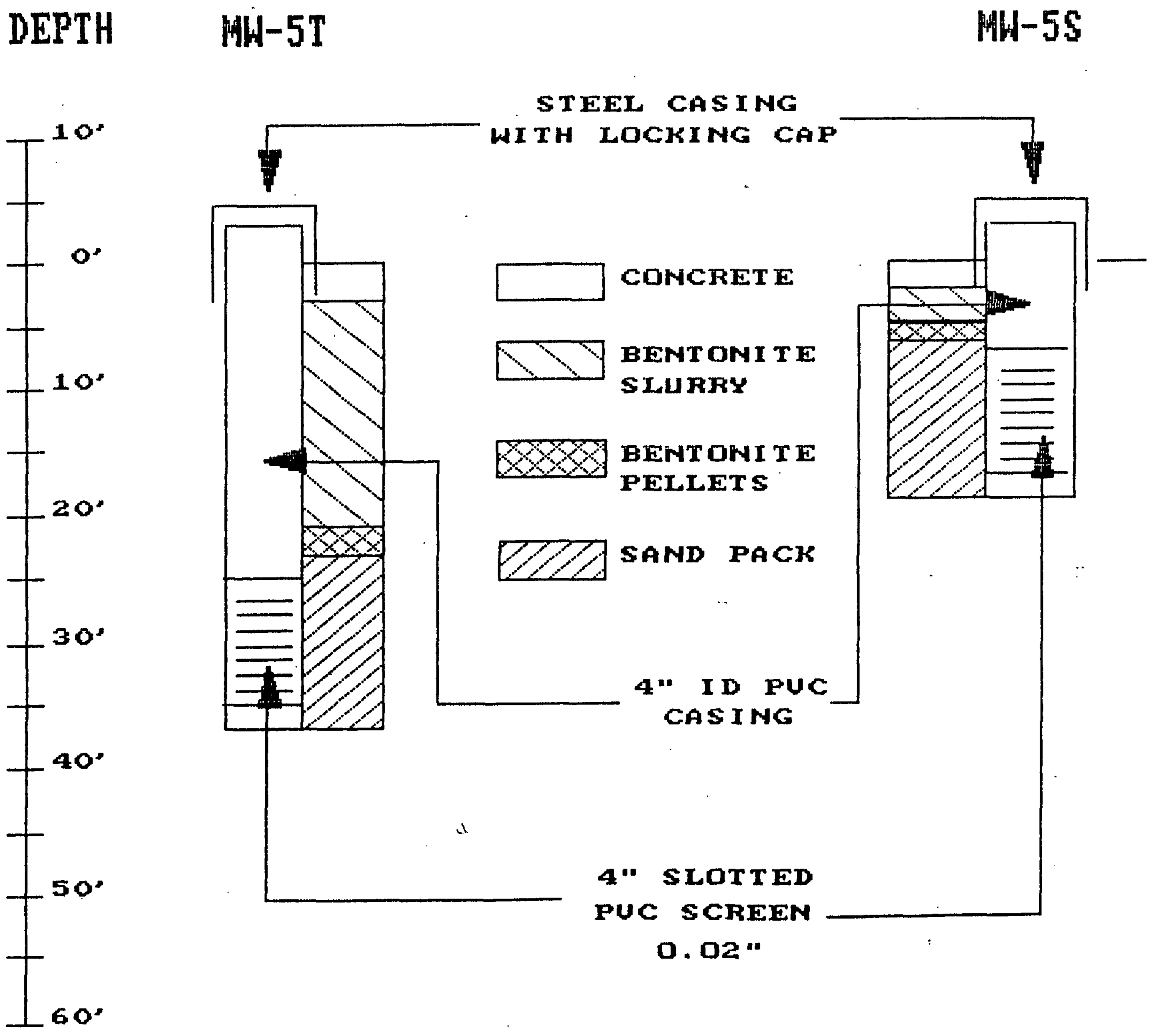
MONITORING WELL DESCRIPTION
GEOLOGIC LOG

DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: MAY 28, 1987
LOGGED BY: JOHN BUCKLEY



MONITORING WELL DESCRIPTION
AS BUILT DRAWING

DRILLER: TESTWELL CRAIG TEST BORING
DATE DRILLED: MAY 28, 1987



DWR-133 (5/85)

STATE OF NEW JERSEY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATER RESOURCES
TRENTON, N.J.

Mail to

Water Allocation
CN 029
Trenton, N.J. 08625

2410337

Permit No. 2410337

01

PERMIT TO DRILL WELL

VALID ONLY AFTER APPROVAL BY THE D.E.P. 10 WELLS 26421

Owner AMERICAN CYANAMID CO.
Address PO BOX 31
LINDEN, NJ

Driller TOM WARD / TESTWELL CRAIG
Address PO BOX 477
MAYS LANDING, NJ

Name of Facility SLUDGE IMPOUND AREA
Address WARNER'S PLANT
~~[illegible]~~ ~~[illegible]~~ CARTERET NJ

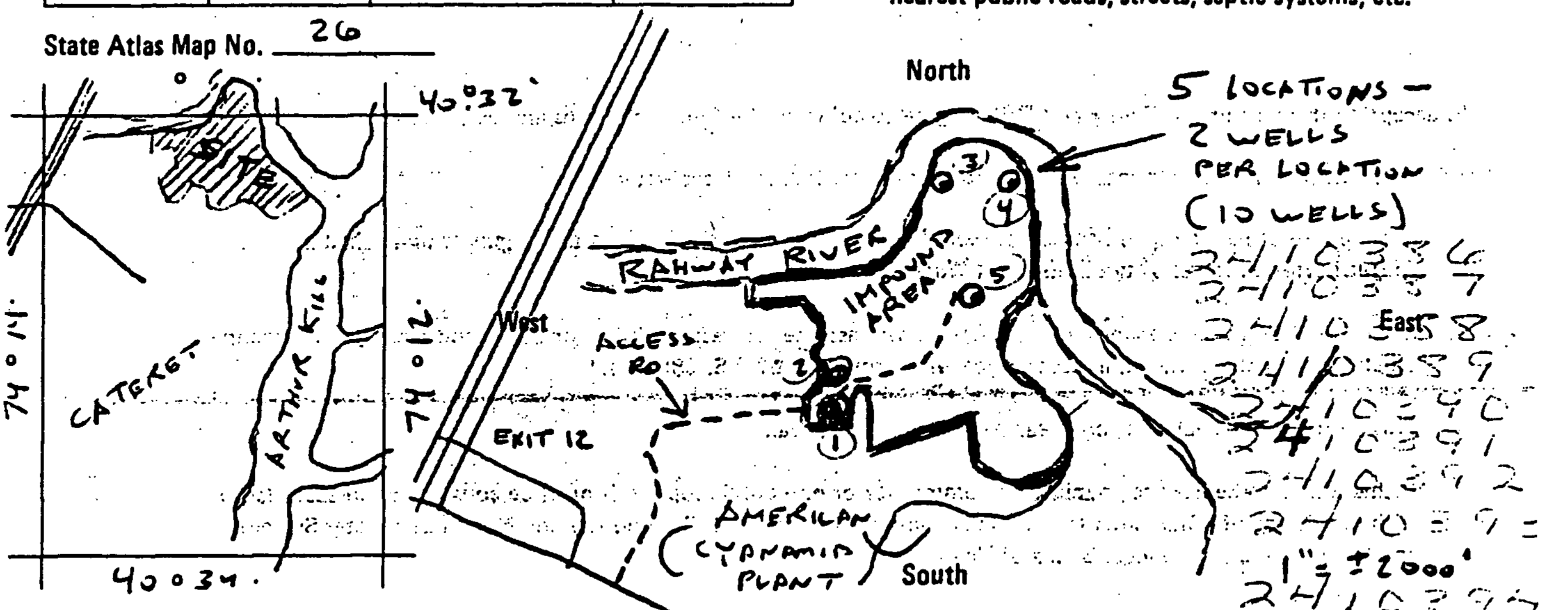
Diameter of Well	4 Inches	Proposed Depth of Well	±25 Ft.
Proposed Capacity of Pump	—— GPM	Method of Drilling (cable-tool, rotary, etc.)	AUGER
Use of Well (See Reverse)	GW MONITORING		

LOCATION OF WELL

Lot #	Block #	Municipality	County
—	—	CARTERET	MIDDLESEX

Draw sketch showing distance and relations of well site to nearest public roads, streets, septic systems, etc.

State Atlas Map No. 26



SEE REVERSE SIDE for IMPORTANT PROVISIONS AND REGULATIONS pertaining to this permit. APPROVAL of this permit is made SUBJECT TO acceptance of and compliance with the following ADDITIONAL CONDITIONS.

- ☐ Pinelands - Well must be drilled over 100' deep or a clay layer at least 4' in thickness must be encountered.
- ☐ It is necessary that Geophysical Logs of this well be made. Permanent pumping equipment SHALL NOT be installed until such logs are made.
- ☐ Authorization by rule under N.J.A.C. 7:14A-1 et seq.
- ☐ Samples of cuttings required every ______________ feet or change in material.
- ☐ The results of a volatile organic scan mut be obtained prior to using the water and submitted to ______________________________
- ☐ Domestic Potable Water Supply - The service line for water from the public community water supply system shall be turned off at the curb cock, and the meter shall be removed by the water purveyor.
- ☐ Domestic Irrigation Supply - No piping from the well for which the permit applies shall enter any building.
- ☐ Industrial/Commercial Supply - A physical connection permit shall be obtained pursuant to the provisions of N.J.A.C. 7:10-10-1 et seq., and a vigorous cross connections control program shall be instituted and maintained within the premises.
- ☐ Heat Pump Wells - Wells must be 50 feet apart and the water must be returned to the same aquifer as the production well.
- ☐ ______________________________

This Space for Approval Stamp

WELL PERMIT APPROVED
Dept. of Environmental Protection
Water Resources/Water Allocation

MAR 18 1987

In compliance with R.S. 58:4A-14, application is made for a permit to drill a well as described above.

Date ______________________ Signature of Owner ______________________

COPIES: *Water Allocation — White* *Health Dept. — Yellow* *Owner — Blue* *Driller — White*

USE OF WELL:

Please Specify

Domestic	Heat Pump
Deepening	Recharge
Replacement	Test
Irrigation	Industrial
Observation	Commercial
Monitoring	Public Supply
Exploration	Non-Community
Dewatering	Fire Protection
Recovery	Decontamination

Application must be accompanied by a legal fee of ten dollars ($10.00) for wells under 70 gallons per minute and twenty five dollars ($25.00) for over 70 gallons per minute.

Make Checks Payable to: **STATE OF NEW JERSEY – WELL PERMITS**

In accepting this permit the Owner and Driller agree to abide by the following terms and conditions:

1. **This permit conveys no rights, either expressed or implied, to divert water.**
2. **If the pump capacity applied for is less than 70 gpm, no subsequent increase to 70 gpm or more shall be made without prior approval of the Division of Water Resources.**
3. **In the event this well is abandoned, the Owner will assume full responsiblity for filling and sealing it in a manner satisfactory to the Division, in accordance with provisions of R.S. 58:4A-4.1.**
4. **This permit will be valid for one year from date of approval.**
5. **If this well is to be used for public non-community or non-public supply, it must be constructed in accordance with provisions of "Standards for the Construction of Public Non-Community and Non-Public Water Systems" and be approved by the local Board of Health.**
6. **A well record must be filed with the Water Allocation Office within 60 days after the well is completed.**
7. **Authorization by rule may be revoked at any time.**

MONITORING WELL CERTIFICATION ...

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 -1 0 3 8 6 -
Owner's Well Number (As shown on the application or plans):	MW-1T
Well Completion Date:	5-3-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3"
Total Depth of Well (one-hundredth of a foot):	52'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	45'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	18'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

AUTHENTICATION

I certify under penalty of law that, where applicable, I meet the requirements as specified on the reverse of this page, that I have personally examined and am familiar with the information submitted in this document and all attachments, and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Ken Hamilton
NAME (TYPE OR PRINT)

SIGNATURE

N.J. License #1297
CERTIFICATION OR LICENSE NUMBER

SEAL

Testwell Craig Test Boring Co., Inc.
CERTIFICATION BY EXECUTIVE OFFICER OR DULY AUTHORIZED REPRESENTATIVE

F. Gordon Craig
NAME (TYPE OR PRINT)

F. Gordon Craig
SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL CERTIFICATION - FORM A - AS-BUILT CERTIFICATION
(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 - 1 0 3 8 7 -
Owner's Well Number (As shown on the application or plans):	MW-1 S
Well Completion Date:	7-6-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3'
Total Depth of Well (one-hundredth of a foot):	20'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	13'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	17'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

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F. Gordon Craig
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F. Gordon Craig
SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL [illegible]

(One form must be completed for each well)

Name of Permittee: American Cvanamid Co.

Name of Facility: American Cvanamid Sanitary Landfill - Carteret

Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	24-10388
Owner's Well Number (As shown on the application or plans):	MW-2T
Well Completion Date:	6-26-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3"
Total Depth of Well (one-hundredth of a foot):	52'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	45'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	20'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

AUTHENTICATION

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Ken Hamilton — NAME (TYPE OR PRINT)

[signature] — SIGNATURE

N.J. License #1297 — CERTIFICATION OR LICENSE NUMBER

SEAL

Testwell Craig Test Boring Co., Inc. — CERTIFICATION BY EXECUTIVE OFFICER OR DULY AUTHORIZED REPRESENTATIVE

F. Gordon Craig — NAME (TYPE OR PRINT)

F. Gordon Craig — SIGNATURE

President — TITLE

12-16-87 — DATE

[illegible]

(One form must be completed for each well)

Name of Permittee:	American Cvanamid Co.
Name of Facility:	American Cvanamid Sanitary Landfill - Carteret
Location:	

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 - 1 0 3 8 9 -
Owner's Well Number (As shown on the application or plans):	MW-2S
Well Completion Date:	6-26-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3"
Total Depth of Well (one-hundredth of a foot):	20'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	13'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material; (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	18'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

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F. Gordon Craig
NAME (TYPE OR PRINT)

SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL [illegible]

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.

Name of Facility: American Cyanamid Sanitary Landfill - Carteret

Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)): 24-10390-

Owner's Well Number (As shown on the application or plans): MW-3T

Well Completion Date: 7-28-87

Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot): 3'

Total Depth of Well (one-hundredth of a foot): 60'

Depth to Top of Screen From Top of Casing (one-hundredth of a foot): 53'

Screen Length (feet): 10'

Screen or Slot Size: .020"

Screen or Slot Material: Sch. 40 PVC

Casing Material: (PVC, Steel or Other-Specify): Sch. 40 PVC

Casing Diameter (Inches): 4"

Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot): 20'

Yield (Gallons per Minute): 8 +

Length of time Well Pumped or Bailed: 1 Hours - Minutes

Lithologic Log: ATTACH

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SIGNATURE

President

TITLE

12-16-87

DATE

MONITORING WELL CERTIFICATION - FORM A - AS-BUILT CERTIFICATION

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.

Name of Facility: American Cyanamid Sanitary Landfill - Carteret

Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 - 1 0 3 9 1 -
Owner's Well Number (As shown on the application or plans):	MW-3S
Well Completion Date:	7-28-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3'
Total Depth of Well (one-hundredth of a foot):	30'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	23'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	19'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

AUTHENTICATION

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F. Gordon Craig
SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL RECORD

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 - 1 0 3 9 2 -
Owner's Well Number (As shown on the application or plans):	MW-4T
Well Completion Date:	7-24-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3'
Total Depth of Well (one-hundredth of a foot):	60'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	53'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	18'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

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F. Gordon Craig
SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL CERTIFICATION - FORM A - AS BUILT

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)):	2 4 - 1 0 3 9 3 -
Owner's Well Number (As shown on the application or plans):	MW-4S
Well Completion Date:	7-24-87
Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot):	3'
Total Depth of Well (one-hundredth of a foot):	25'
Depth to Top of Screen From Top of Casing (one-hundredth of a foot):	18'
Screen Length (feet):	10'
Screen or Slot Size:	.020"
Screen or Slot Material:	Sch. 40 PVC
Casing Material: (PVC, Steel or Other-Specify):	Sch. 40 PVC
Casing Diameter (Inches):	4"
Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot):	19'
Yield (Gallons per Minute):	8 +
Length of time Well Pumped or Bailed	1 Hours - Minutes
Lithologic Log:	ATTACH

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F. Gordon Craig
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President
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12-16-87
DATE

MONITORING WELL CERTIFICATION - FORM A - AS-BUILT CERTIFICATION

(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)): 2 4 - 1 0 3 9 4 - _

Owner's Well Number (As shown on the application or plans): MW-5T

Well Completion Date: 5-28-87

Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot): 3"

Total Depth of Well (one-hundredth of a foot): 47'

Depth to Top of Screen From Top of Casing (one-hundredth of a foot): 40'

Screen Length (feet): 10'

Screen or Slot Size: .020"

Screen or Slot Material: Sch. 40 PVC

Casing Material: (PVC, Steel or Other-Specify): Sch. 40 PVC

Casing Diameter (Inches): 4"

Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot): 20'

Yield (Gallons per Minute): 8 +

Length of time Well Pumped or Bailed: 1 Hours - Minutes

Lithologic Log: ATTACH

AUTHENTICATION

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SIGNATURE

President
TITLE

12-16-87
DATE

MONITORING WELL CERTIFICATION FORM
(One form must be completed for each well)

Name of Permittee: American Cyanamid Co.
Name of Facility: American Cyanamid Sanitary Landfill - Carteret
Location:

NJPDES Permit No: NJ 0061611

CERTIFICATION

Well Permit Number (As assigned by NJDEP's Well Drilling Perits Section (609 - 984-6831)): 2 4 - 1 0 3 9 5 -

Owner's Well Number (As shown on the application or plans): MW-5S

Well Completion Date: 5-28-87

Distance from Top of Casing (cap off) to ground surface (one-hundredth of a foot): 3'

Total Depth of Well (one-hundredth of a foot): 20'

Depth to Top of Screen From Top of Casing (one-hundredth of a foot): 13'

Screen Length (feet): 10'

Screen or Slot Size: .020"

Screen or Slot Material: Sch. 40 PVC

Casing Material: (PVC, Steel or Other-Specify): Sch. 40 PVC

Casing Diameter (Inches): 4"

Static Water Level From Top of Casing at The Time of Installation (one-hundredth of a foot): 19'

Yield (Gallons per Minute): 8 +

Length of time Well Pumped or Bailed: 1 Hours - Minutes

Lithologic Log: ATTACH

AUTHENTICATION

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F. Gordon Craig
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F Gordon Craig
SIGNATURE

President
TITLE

12-16-87
DATE

APPENDIX B

EP Toxicity (Metals) and Cyanide Analyses
for Sludge, and Grab Samples
of Leachate, Groundwater, and Surface Water
Conducted in May 1986

RESULTS OF ANALYSIS FOR EP TOXIC METALS

AND CYANIDE IN SAMPLES COLLECTED ON 16 MAY 1986

BY HYDROSYSTEMS, INC.

Prepared for

Hydrosystems, Inc.
P.O. Box 348
Dunn Loring, VA 22027

Prepared by
Martin Marietta Environmental Systems
9200 Rumsey Road
Columbia, MD 21045

24 July 1986

ANALYTICAL REPORT

On 19 May 1986, Martin Marietta Environmental Systems received 8 aqueous samples and 5 sludge samples collected on 16 May 1986 by Hydrosystems, Inc. A list of the samples received and corresponding laboratory tracking numbers is shown in Table 1. Additional sample information can be found on the enclosed chain of custody forms included as Appendix A.

Samples were analyzed for free cyanide using Method 412 as specified in "Standard Methods," 16th Edition, 1985, and total cyanide using Method 335.2 as specified in "Standard Methods for Chemical Analysis of Water and Wastes," EPA-600/4-79-020, revised March 1983. The EP Toxicity test was performed on the sludge samples and the leachates analyzed for metals using Method 1310 as specified in SW-846 (2nd edition), "Test Methods for Evaluating Solid Waste," USEPA, 1982. Results of analyses are presented in Tables 2 and 3. Quality control sample data are contained in Appendix B. Maximum concentrations of metals for determining the EP Toxicity characteristic are given in Appendix C.

Table 1. List of samples received on 19 May 1986 and corresponding laboratory tracking numbers

Hydrosystems, Inc. Sample I.D.		Martin Marietta Environmental Systems Lab I.D.
CART-2	5/16/86	3352
CART-4	5/16/86	3353
CART-5	5/16/86	3354
CART-6	5/16/86	3355
CART-7	5/16/86	3356
CART-8	5/16/86	3357
CART-9	5/16/86	3358
Trip Blank	5/12/86	3359
Sludge-C1	5/16/86	3360
Sludge-C2	5/16/86	3361
Sludge-C3	5/16/86	3362
Sludge-C4	5/16/86	3363
Sludge-C5	5/16/86	3364

Table 2. Results of EP Toxicity analysis for metals in sludge samples collected on 16 May 1986 by Hydrosystems, Inc.

Reported as total metals from EP TOX extract   Units: ppb (µg/L)

MMES ID			3360	3361	3361 (a)	3362	3363	3363 (b)	3364	Prep Blank (c)
Client ID			C1	C2	C2	C3	C4	C4	C5	
Sample Date			5/16/86	5/16/86	5/16/86	5/16/86	5/16/86	5/16/86	5/16/86	
Metal	Method	Analysis Date								
Arsenic	ICP(d)	6/16/86	< 200	< 200	—(e)	< 200	< 200	< 200	< 200	< 200
Barium	ICP	6/12/86	< 200	< 200	—	< 200	< 200	< 200	< 200	< 200
Cadmium	ICP	6/16/86	< 50	< 50	—	< 50	< 50	< 50	< 50	< 50
Chromium	ICP	6/16/86	< 50	< 50	—	< 50	< 50	< 50	< 50	< 50
Lead	ICP	6/16/86	< 200	< 200	—	< 200	< 200	< 200	< 200	< 200
Mercury	CV(f)	6/3/86	< 0.3	< 0.3	< 0.3	0.57	0.69	—	< 0.3	< 0.3
Selenium	ICP	6/16/86	< 200	< 200	—	< 200	< 200	< 200	< 200	< 200
Silver	ICP	6/16/86	< 50	< 50	—	< 50	< 50	< 50	< 50	< 50

(a) Duplicate aliquot of extract analyzed
(b) Duplicate sample extraction and analysis
(c) Laboratory reagent water analyzed
(d) Inductively coupled plasma spectrometry
(e) Sample not analyzed for this parameter
(f) Cold vapor atomic absorption spectroscopy

Table 3. Results of analysis for free and total cyanide in samples collected on 16 May 1986 by Hydrosystems, Inc.

MMES Lab ID	Hydrosystems Sample ID	Total Cyanide (mg/L)	Free Cyanide (mg/L)
3352	CART-2	85	0.33
3353	CART-4	124	2.4
3354	CART-5	105	0.50
3355	CART-6	62	2.3
3356	CART-7	49	0.55
3357	CART-8	2	0.084
3358	CART-9	0.37	0.012
3359	Trip Blank	0.013	0.007

MMES Lab ID	Hydrosystems Sample ID	Total Cyanide (mg/kg)	Free Cyanide (mg/kg)
3360	C1	683	14
3361	C2	452	18
3362	C3	3660	103
3363	C4	437	38
3364	C5	433	9

APPENDIX A

CHAIN OF CUSTODY RECORD

MARTIN MARIETTA ENVIRONMENTAL SYSTEMS CHAIN OF CUSTODY	9200 Rumsey Road Columbia, MD 21045-1934 (301)964-9200 FAX #(301)964-9200, Ext. 361

Client: HYDROSYSTEMS, Inc
Client Address: 2042 Peach Orchard Drive
Falls Church VA 22043

Contact Person: Lyle R. Silka   phone (703) 573-1690

Sampled by: Lyle R. Silka   Date: 5-16-86

	Client sample identification	Location/Test Parameters	Sampling date/time	# of samples/ volume	preservative
3352	CART-2	Free + Total CN⁻	5-16-86	~1 l	NaOH
3353	CART-4	"	"	"	"
3354	CART-5	"	"	"	"
3355	CART-6	"	"	"	"
3356	CART-7	"	"	"	"
3357	CART-8	"	"	"	"
3358	CART-9	"	"	"	"
3359	Trip Blank	"	5-12-86	"	"

released by:	date/time	received by:	date/time:
Lyle R. Silka	5-19-86/1107		
released by:	date/time	received by:	date/time:

received in laboratory by:	date/time	method of shipment:
A. Baker Smiley	5/19 11:30	Ice Chest

comments:
Run for Free + Total CN⁻

MARTIN MARIETTA ENVIRONMENTAL SYSTEMS CHAIN OF CUSTODY	9200 Rumsey Road Columbia, MD 21045-1934 (301)964-9200 FAX #(301)964-9200, Ext. 361

Client: HYDROSYSTEMS, Inc

Client Address: 2042 Peach Orchard Dr.
Falls Church VA 22043

Contact Person: Lyle R. Silka phone: (703) 573-1690

Sampled by: Lyle R. Silka Date: 5-16-86

	Client sample identification	Location/Test Parameters	Sampling date/time	# of samples/ volume	preservative
3360	Sludge - C1	EPTox Metals +	5/16/86	500gm	Refrig
3361	Sludge - C2	Free + Total CN	"	"	"
3362	Sludge - C3	"	"	"	"
3363	Sludge - C4	"	"	"	"
3364	Sludge - C5	"	"	"	"

released by:	date/time	received by:	date/time:
Lyle R. Silka	5/19/86/1120		
released by:	date/time	received by:	date/time:
received in laboratory by:	date/time	method of shipment:	
A. Brooke Smulson	5/19 11:30		

comments: EP TOX Metals + Free + Total CN⁻

APPENDIX B

QUALITY CONTROL SAMPLE DATA

Table B-1. QC Summary -- Blanks

|✓| METALS |_| NON-METALS |_| PHYSICAL

MMES ID # 3360-64

Matrix EP TOX Leachate Analysis Type EP TOX Units ppb

Parameter	Detection Limit	Blanks (Prep)	Method
Arsenic	200	< 200	ICP
Barium	200	< 200	ICP
Cadmium	50	< 50	ICP
Chromium	50	< 50	ICP
Lead	200	< 200	ICP
Mercury	0.3	< 0.3	Cold Vapor
Selenium	200	< 200	ICP
Silver	50	< 50	ICP

Table B-2. QC Summary -- Duplicate Analysis

One sample per batch received was analyzed as a laboratory duplicate. The Relative Percent Difference (RPD) was calculated and interpreted according to the Contract Laboratory Program (CLP) Statement of Work 7/85 (see clarifications below the table). Sample (S) and duplicate (D) values and their RPD's are listed in the table below:

MMES ID # 3360-64

Analysis Type EP TOX Units ppb

Parameter	MMES ID	Detection Limit (DL)	Sample	Duplicate	RPD[a]
Arsenic	3363	200	< 200	< 200	NC [b]
Barium	3363	200	< 200	< 200	NC
Cadmium	3363	50	< 50	< 50	NC
Chromium	3363	50	< 50	< 50	NC
Lead	3363	200	< 200	< 200	NC
Mercury	3361	0.3	< 0.3	< 0.3	NC
Selenium	3363	200	< 200	< 200	NC
Silver	3363	50	< 50	< 50	NC

(a) RPD = [(S-D)/(S+D)/2] X 100
(b) RPD not calculated (NC), result < DL

Table B-3. QC Summary -- Spiked Sample Recoveries

One sample per batch was spiked and analyzed for the parameters listed in the table below. Spike sample result (SSR), sample result (SR), spike added (SA), and the percent recovery (%R) are also listed in the table below.

Parameter	MMES ID	Control Limits	Spiked Sample Result (SSR)	Sample Result (SR)	Spike Added (SA)	%R[a]
Arsenic	3364	75-125%	574	24	500	110
Barium	3364	75-125	552	79	100	95
Cadmium	3364	75-125	72	1	100	71[b]
Chromium	3364	75-125	162	10	200	76
Lead	3364	75-125	439	24	500	83
Mercury	3364	75-125	50	1.3[c]	50	97
Selenium	3364	75-125	521	53	500	94
Silver	3364	75-125	85	3	100	82

(a) %R = [(SSR-SR)/SA] X 100
(b) Low spike recovery was judged to have no effect on data submitted since no samples contained cadmium.
(c) Value represents concentration measured in 35 mL aliquot. Final concentration is less than detection limit.

APPENDIX C

MAXIMUM CONCENTRATION OF CONTAMINANTS

FOR CHARACTERISTIC OF EP TOXICITY

MAXIMUM CONCENTRATION OF CONTAMINANTS

FOR CHARACTERISTIC OF EP TOXICITY*

Contaminant	Maximum Concentration mg/L	ppb
Arsenic	5.0	5,000
Barium	100.0	100,000
Cadmium	1.0	1,000
Chromium	5.0	5,000
Lead	5.0	5,000
Mercury	0.2	200
Selenium	1.0	1,000
Silver	5.0	5,000

* From SW-846 (2nd Edition), "Test Methods for Evaluating Solid Waste," USEPA, 1982

APPENDIX C

Hydrologic Budget Analysis

CARTERET IMPOUNDMENTS

WATER BUDGET PRIOR TO REVEGETATION

****

PERCOLATION CALCULATION

CONDITIONS: REMEDIATED

SOIL TYPE =	SILT	AVERAGE SOIL THICKNESS (IN)	=	12	AREA (ACRES)	=	100
COVER:		ESTIMATED SOIL POROSITY (%)	=	40	AREA (SQFT)	=	4356000
GRASS (%) =	5	MAX SOIL MOISTURE STORAGE (IN)	=	4.8			
TREES (%) =	0						

MONTH	NUMBER OF MONTH	AVERAGE PRECIP (IN/MONTH)	POT ET (IN/MONTH)	SURFACE RUNOFF % OF PRECIP	SURFACE RUNOFF (IN/MONTH)	INFILTRATION (IN/MONTH)	INFILT-POT ET (IN/MONTH)	SOIL MOISTURE STORAGE	CHANGE IN SOIL MOIST STORAGE	ACTUAL ET (IN/MONTH)	PERCOLATION (IN/MONTH)
JAN	1	2.91	0.00	80	2.33	0.58	0.58	4.80	0.00	0.00	0.58
FEB	2	2.95	0.00	80	2.36	0.59	0.59	4.80	0.00	0.00	0.59
MAR	3	3.93	0.03	70	2.75	1.18	1.15	4.80	0.00	0.03	1.15
APR	4	3.44	0.08	70	2.41	1.03	0.95	4.80	0.00	0.08	0.95
MAY	5	3.60	0.14	60	2.16	1.44	1.30	4.80	0.00	0.14	1.30
JUN	6	2.99	0.20	50	1.50	1.50	1.29	4.80	0.00	0.20	1.29
JUL	7	4.03	0.24	30	1.21	2.82	2.58	4.80	0.00	0.24	2.58
AUG	8	4.27	0.23	15	0.64	3.63	3.40	4.80	0.00	0.23	3.40
SEP	9	3.44	0.18	30	1.03	2.41	2.23	4.80	0.00	0.18	2.23
OCT	10	2.82	0.11	50	1.41	1.41	1.30	4.80	0.00	0.11	1.30
NOV	11	3.61	0.05	70	2.53	1.08	1.03	4.80	0.00	0.05	1.03
DEC	12	3.46	0.00	80	2.77	0.69	0.69	4.80	0.00	0.00	0.69
ANNUAL AVERAGE (IN/YR)		41.45	1.26	57	23.09	18.36			0.00	1.26	17.10

ERROR CHECK (% PRECIP) = 0

TOTAL ANNUAL DISCHARGE FROM AREA

DISCHARGE VIA GROUNDWATER (CFY) =	6208718	DISCHARGE VIA SURFACE WATER (CFY) =	8381126	TOTAL DISCHARGE (CFY) =	14589843
DISCHARGE VIA GROUNDWATER (CFD) =	17010	DISCHARGE VIA SURFACE WATER (CFD) =	22962	TOTAL DISCHARGE (CFD) =	39972
DISCHARGE VIA GROUNDWATER (CFS) =	0.197	DISCHARGE VIA SURFACE WATER (CFS) =	0.266	TOTAL DISCHARGE (CFS) =	0.463

****

POTENTIAL EVAPOTRANSPIRATION CALCULATION

WATER BUDGET PRIOR TO REVEGETATION

MONTH	NUMBER OF MONTH	MONTHLY MEAN TEMP (F)	MONTHLY MEAN TEMP (C)	MONTHLY HEAT INDEX	POT ET (IN/MONTH)	POT ET FOR GRASSES (IN/MONTH)	POT ET FOR FOREST (IN/MONTH)	TOTAL POT ET (IN/MONTH)
JAN	1	31.4	-0.33	0.00	0.00	0.00	0.00	0.00
FEB	2	32.6	0.33	0.00	0.01	0.00	0.00	0.00
MAR	3	40.6	4.78	0.93	0.50	0.03	0.00	0.03
APR	4	51.7	10.94	3.27	1.57	0.08	0.00	0.08
MAY	5	61.9	16.61	6.16	2.78	0.14	0.00	0.14
JUN	6	71.4	21.89	9.35	4.07	0.20	0.00	0.20
JUL	7	76.4	24.67	11.21	4.79	0.24	0.00	0.24
AUG	8	74.6	23.67	10.52	4.53	0.23	0.00	0.23
SEP	9	67.8	19.89	8.09	3.57	0.18	0.00	0.18
OCT	10	57.5	14.17	4.84	2.24	0.11	0.00	0.11
NOV	11	46.2	7.89	1.99	1.00	0.05	0.00	0.05
DEC	12	34.5	1.39	0.00	0.09	0.00	0.00	0.00
			SUM OF i =	56.37	25.15	1.26	0.00	1.26
			a =	1.37				

SEASONAL VARIATION OF RUNOFF AS A PERCENT OF P
WATER BUDGET PRIOR TO REVEGETATION

****

MONTH	NUMBER OF MONTH	SCS ANTECEDENT MOISTURE CONDITION	RUNOFF % OF PRECIP
JAN	1	III	80
FEB	2	III	80
MAR	3	III	70
APR	4	III	70
MAY	5	II	60
JUN	6	II	50
JUL	7	I	30
AUG	8	I	15
SEP	9	I	30
OCT	10	II	50
NOV	11	III	70
DEC	12	III	80
ANNUAL AVERAGE			57

****

CARTERET IMPOUNDMENTS

WATER BUDGET AFTER REVEGETATION

PERCOLATION CALCULATION

CONDITIONS: REMEDIATED

SOIL TYPE =	SILT	AVERAGE SOIL THICKNESS (IN)	=	12	AREA (ACRES)	=	100
COVER:		ESTIMATED SOIL POROSITY (%)	=	40	AREA (SQFT)	=	4356000
GRASS (%) =	100	MAX SOIL MOISTURE STORAGE (IN)	=	4.8			
TREES (%) =	0						

MONTH	NUMBER OF MONTH	AVERAGE PRECIP (IN/MONTH)	POT ET (IN/MONTH)	SURFACE RUNOFF % OF PRECIP	SURFACE RUNOFF (IN/MONTH)	INFILTRATION (IN/MONTH)	INFILT-POT ET (IN/MONTH)	SOIL MOISTURE STORAGE	CHANGE IN SOIL MOIST STORAGE	ACTUAL ET (IN/MONTH)	PERCOLATION (IN/MONTH)
JAN	1	2.91	0.00	40	1.16	1.75	1.75	4.80	0.00	0.00	1.75
FEB	2	2.95	0.01	40	1.18	1.77	1.76	4.80	0.00	0.01	1.76
MAR	3	3.93	0.50	35	1.38	2.55	2.05	4.80	0.00	0.50	2.05
APR	4	3.44	1.57	35	1.20	2.24	0.67	4.80	0.00	1.57	0.67
MAY	5	3.60	2.78	12	0.43	3.17	0.38	4.80	0.00	2.78	0.38
JUN	6	2.99	4.07	12	0.36	2.63	-1.44	3.36	-1.44	4.07	0.00
JUL	7	4.03	4.79	10	0.40	3.63	-1.17	3.63	0.27	3.36	0.27
AUG	8	4.27	4.53	5	0.21	4.06	-0.47	4.33	0.69	3.36	0.69
SEP	9	3.44	3.57	10	0.34	3.10	-0.47	4.33	0.00	3.09	0.00
OCT	10	2.82	2.24	12	0.34	2.48	0.25	4.80	0.47	2.24	0.25
NOV	11	3.61	1.00	35	1.26	2.35	1.35	4.80	0.00	1.00	1.35
DEC	12	3.46	0.09	40	1.38	2.08	1.98	4.80	0.00	0.09	1.98
ANNUAL AVERAGE (IN/YR)		41.45	25.15	24	9.66	31.79			0.00	22.08	11.15

ERROR CHECK (% PRECIP) = -3

TOTAL ANNUAL DISCHARGE FROM AREA

DISCHARGE VIA GROUNDWATER (CFY) =	4047566	DISCHARGE VIA SURFACE WATER (CFY) =	3506834	TOTAL DISCHARGE (CFY) =	7554400
DISCHARGE VIA GROUNDWATER (CFD) =	11089	DISCHARGE VIA SURFACE WATER (CFD) =	9608	TOTAL DISCHARGE (CFD) =	20697
DISCHARGE VIA GROUNDWATER (CFS) =	0.128	DISCHARGE VIA SURFACE WATER (CFS) =	0.111	TOTAL DISCHARGE (CFS) =	0.240

POTENTIAL EVAPOTRANSPIRATION CALCULATION
WATER BUDGET AFTER REVEGETATION

MONTH	NUMBER OF MONTH	MONTHLY MEAN TEMP (F)	MONTHLY MEAN TEMP (C)	MONTHLY HEAT INDEX	POT ET (IN/MONTH)	POT ET FOR GRASSES (IN/MONTH)	POT ET FOR FOREST (IN/MONTH)	TOTAL POT ET (IN/MONTH)
JAN	1	31.4	-0.33	0.00	0.00	0.00	0.00	0.00
FEB	2	32.6	0.33	0.00	0.01	0.01	0.00	0.01
MAR	3	40.6	4.78	0.93	0.50	0.50	0.00	0.50
APR	4	51.7	10.94	3.27	1.57	1.57	0.00	1.57
MAY	5	61.9	16.61	6.16	2.78	2.78	0.00	2.78
JUN	6	71.4	21.89	9.35	4.07	4.07	0.00	4.07
JUL	7	76.4	24.67	11.21	4.79	4.79	0.00	4.79
AUG	8	74.6	23.67	10.52	4.53	4.53	0.00	4.53
SEP	9	67.8	19.89	8.09	3.57	3.57	0.00	3.57
OCT	10	57.5	14.17	4.84	2.24	2.24	0.00	2.24
NOV	11	46.2	7.89	1.99	1.00	1.00	0.00	1.00
DEC	12	34.5	1.39	0.00	0.09	0.09	0.00	0.09
			SUM OF i =	56.37	25.15	25.15	0.00	25.15
			a =	1.37				

SEASONAL VARIATION OF RUNOFF AS A PERCENT OF P
WATER BUDGET AFTER REVEGETATION

****

MONTH	NUMBER OF MONTH	SCS ANTECEDENT MOISTURE CONDITION	RUNOFF % OF PRECIP
JAN	1	III	40
FEB	2	III	40
MAR	3	III	35
APR	4	III	35
MAY	5	II	12
JUN	6	II	12
JUL	7	I	10
AUG	8	I	5
SEP	9	I	10
OCT	10	II	12
NOV	11	III	35
DEC	12	III	40
ANNUAL AVERAGE			24

****

APPENDIX D

Cyanide Analyses for Surface Water Samples
Conducted in October 1986

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF ANALYTICAL RESULTS
FOR TOTAL AND FREE CYANIDE
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING LOCATION DESCRIPTION	CYANIDE CONCENTRATION (IN MG/L)	
		TOTAL	FREE
THE FOLLOWING SAMPLES WERE COLLECTED JUST BEFORE HIGH TIDE RIVER FLOW IS INLAND			
H1	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
H2	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
H3	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
H4	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
H5	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
H6	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
H16	DUPLICATE SAMPLE OF NO. H6	BDL	BDL
H20	FIELD BLANK	BDL	BDL

BDL = BELOW DETECTION LIMIT OF 0.025 MG/L

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF ANALYTICAL RESULTS
FOR TOTAL AND FREE CYANIDE
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING LOCATION DESCRIPTION	CYANIDE CONCENTRATION (IN MG/L)	
		TOTAL	FREE
THE FOLLOWING SAMPLES WERE COLLECTED JUST BEFORE LOW TIDE RIVER FLOW IS SEAWARD			
L1	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
L2	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
L12	DUPLICATE SAMPLE OF NO. L2	BDL	BDL
L3	UPSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
L4	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM FAR BANK	BDL	BDL
L5	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER MID STREAM	BDL	BDL
L15	DUPLICATE SAMPLE OF NO. L5	BDL	BDL
L6	DOWNSTREAM OF IMPOUNDS IN RAHWAY RIVER 1/4 STREAM WIDTH FROM NEAR BANK	BDL	BDL
L7	UPSTREAM OF IMPOUNDS IN MARSH CREEK FAR BANK OF RAHWAY RIVER	BDL	BDL
L8	UPSTREAM OF IMPOUNDS IN CROSS CREEK NEAR BANK OF RAHWAY RIVER	0.032	0.032
L20	FIELD BLANK	BDL	BDL

BDL = BELOW DETECTION LIMIT OF 0.025 MG/L

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF FIELD DATA ON TOTAL AND SAMPLING DEPTH,
TEMPERATURE, SALINITY, AND SPECIFIC CONDUCTIVITY
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING TIME (24 HOUR)	TOTAL DEPTH (FT)	SAMPLING DEPTH (FT)	TEMP (CELSIUS)	SALINITY (o/oo)	CONDUCTIVITY (UMHOS/CM)
	DAY: OCTOBER 9, 1986					
H1	1030	5.5	0.0	20.7	15.0	22,000
			2.5	20.5	16.0	23,000
			5.5	21.0	16.0	23,200
H2	1055	11.0	0.0	20.0	19.0	26,000
			5.0	20.0	19.0	26,200
			10.0	20.0	19.5	26,300
H3	1110	5.5	0.0	20.5	19.0	26,500
			2.5	20.2	19.0	26,900
			5.5	20.2	17.5	24,200
H4	1130	7.5	0.0	19.8	20.0	28,000
			3.0	19.0	20.0	28,000
			7.0	19.0	19.9	27,900
H5	1140	13.5	0.0	20.0	19.9	28,000
			6.0	20.0	20.0	28,100
			12.0	20.0	20.9	28,200
H6	1150.	11.5	0.0	20.0	21.5	28,000
			5.0	20.0	21.5	28,200
			10.0	20.0	21.5	28,200
H16	1200 (FIELD DATA SAME AS SAMPLE NO. H6)					
H20	1205 (FIELD BLANK)					

NOTE: HIGH TIDE MAXIMUM AT APPROXIMATELY 1200 HOURS

RAHWAY RIVER SAMPLING PROGRAM
SUMMARY OF FIELD DATA ON TOTAL AND SAMPLING DEPTH,
TEMPERATURE, SALINITY, AND SPECIFIC CONDUCTIVITY
IN SURFACE WATER
NEAR THE CARTERET IMPOUNDS
COLLECTED BY HYDROSYSTEMS, INC.
OCTOBER 9, 1986

HYDROSYSTEMS' SAMPLE ID NUMBER	SAMPLING TIME (24 HOUR)	TOTAL DEPTH (FT)	SAMPLING DEPTH (FT)	TEMP (CELSIUS)	SALINITY (o/oo)	CONDUCTIVITY (UMHOS/CM)
	DAY: OCTOBER 9, 1986					
L1	1655	6.0	3.0	20.5	17.0	24,500
L2	1645	8.5	4.0	20.0	17.9	25,000
L3	1615	3.5	2.0	19.9	18.5	26,000
L4	1730	5.0	2.0	20.0	19.5	27,500
L5	1720	9.0	5.0	20.0	19.5	27,500
L15	1725 (FIELD DATA SAME AS SAMPLE NO. L5)					
L6	1715	4.0	2.0	19.9	19.5	27,500
L7	1705	3.5	1.5	20.0	18.0	25,200
L8	1605	3.5	2.0	19.0	18.9	26,000
L20	1755 (FIELD BLANK)					

NOTE: LOW TIDE MINIMUM AT APPROXIMATELY 1844 HOURS